CX2-136USP2A_ST25

SEQUENCE LISTING

<110> Codexis, Inc.
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<120> ENGINEERED IMINE REDUCTASES AND METHODS FOR THE REDUCTIVE AMINATION OF KETONE AND AMINE COMPOUNDS

<130> CX2-136USP2A

<160> 924

<170> PatentIn version 3.5

<210> 1
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized opine dehydrogenase from Arthrobacter sp. strain 1C [CENDH]

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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

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atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660

tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggtacaag 780

gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat 840

cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900

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ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 2
<211> 359
<212> PRT
<213> Arthrobacter sp. strain 1C

<400> 2

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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Ser Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
85 90 95

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Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Lys Gly Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Val Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Val Asn Ala Val Met His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Gln Tyr Tyr Leu Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ser Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Tyr Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Ala Tyr Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285
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Leu Asn Thr Arg Tyr Phe Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Asp Leu Ile Ser Ser Leu Ile Asp Thr Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Gly Ile Arg Ser Ala Val Glu
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<210>  3
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt      420

acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacagg cgccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

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tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780

gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840

cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900

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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020

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<210> 4
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 4

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Ser Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

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Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Gly Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Val Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Gln Tyr Tyr Leu Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ser Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp His Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285


Leu Asn Thr Val His Phe Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Asp Leu Ile Ser Ser Leu Ile Asp Thr Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Gly Ile Arg Ser Ala Val Glu
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<210> 5
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

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ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 6
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 6

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

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Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255
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Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
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<210> 7
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 7

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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
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gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatggg tgcagggtaa tcctgtgctg 840

cgcggcatta gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

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<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 8

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

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Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
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```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Trp Val Gln Gly Asn Pro Val Leu Arg Gly Ile Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
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<210> 9
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 9

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

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gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 10
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 10

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1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

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Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
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```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 11
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

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ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 12
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 12

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 13
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 13
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatgca tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 14
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 14

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Cys Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 15
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 15
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg catacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatggc tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 16
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 16

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly His Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Trp Leu Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 17
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 17
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgc tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 18

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 18

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Leu Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 19
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 19
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg catacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatgga tgcagggtaa tcctgtgctg 840

cgcggcatta gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 20
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 20

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly His Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Trp Met Gln Gly Asn Pro Val Leu Arg Gly Ile Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 21
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 21
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attccggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 22
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 22

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Pro Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 23
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 23
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 24
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 24

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 25
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 25

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attccggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
```

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 26
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 26

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Pro Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  27
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  27
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 28
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 28

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 29
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 29
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 30
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 30

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 31
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 31
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatgcg tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 32
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 32

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Cys Val Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  33
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  33
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attccggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 34
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 34

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Pro Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 35
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 35
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaatggc tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcgtgga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 36
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 36

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Trp Leu Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Val Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 37
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 37
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg catacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 38
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 38

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly His Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 39
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 39
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcatta gcggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 40
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 40

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Ile Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 41
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 41
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 42

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 42

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 43
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 43
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgtgga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 44
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 44

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Val Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 45
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 45
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcgtga tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 46
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 46

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Val Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 47
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 47
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcaggca aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtat tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttggtgag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 48
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 48

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Gly Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Ile Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Val Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 49
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 49
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcatata aaatctgcag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 50
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 50

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Tyr Lys Ile Cys
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  51
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  51
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tgggcgcgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac      480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggaggaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 52
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 52

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Ala Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Arg Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 53
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 53
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcatata aaatctgcag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acagcgtggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggtggaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttggtgag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 54
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 54

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Tyr Lys Ile Cys
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Ala Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255
```

```
Glu Trp Trp Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Val Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 55
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 55

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtat tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 56
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 56

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255


Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Val Gln Gly Ile Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 57
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 57

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtgc gcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 58
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 58

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

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Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255


Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Val Gln Gly Ala Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 59
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 59
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcatata aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acagcgcgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 60
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 60

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Tyr Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Ala Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 61
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 61
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa acatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acagcgcgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 62
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 62

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Ala Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 63
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 63
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcatata aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acagcgtggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 64
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 64

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Tyr Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Ala Trp Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 65
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 65
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggtggaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 66

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 66

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Trp Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 67
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 67
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtat tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 68
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 68

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255


Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Val Gln Gly Ile Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 69
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 69
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcatata acatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 70
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 70

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Tyr Asn Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 71
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 71
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa acatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

acatgctggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcagtgc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctctgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 72
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 72

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Cys Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Val Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Asn Pro Leu Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 73
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 73
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa acatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtgc gcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttggtgag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 74
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 74

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Val Gln Gly Ala Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Val Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 75
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 75

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa acatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

acagcgtggt ccgagagacc aggacaggtt acggtaaatg cgataacact ggccctggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttggtgag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 76
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 76

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Arg Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Thr Ala Trp Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Cys
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

Ala Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285

Leu Asn Thr Val His Phe Ser Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Val Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 77
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 77
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tgggcgcgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccctggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 78
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 78

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Ala Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Leu Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 79
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 79
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct tagtcctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 80
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 80

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Ser Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 81
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 81

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatc aaataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 82
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 82

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Gln Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 83
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 83
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 84
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 84

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 85
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 85
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagaccgg tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 86
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 86

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 87
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 87
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttatacttct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 88
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 88

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Leu Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 89
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 89
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggacaaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 90

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 90

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Thr Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
        355

<210> 91
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 91
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 92
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 92

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 93
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 93
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttggt 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 94
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 94

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Gly Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 95
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 95
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 96
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 96

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn His Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 97
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 97
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcttggcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 98
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 98

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Leu Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 99
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 99
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga gtcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 100
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 100

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

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Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Ser Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  101
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  101
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttt tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 102
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 102

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 103
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 103
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 104
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 104

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Gly Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 105
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 105

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggtggaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 106
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 106

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Trp Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  107
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  107
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 108
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 108

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 109
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 109
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcacaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 110
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 110

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Thr
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 111
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 111
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 112
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 112

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 113
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 113
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttatacatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 114

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 114

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile His Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 115
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 115
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtaaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 116
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 116

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Lys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 117
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 117
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 118
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 118

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 119
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 119
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagaccag tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 120
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 120

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 121
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 121

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt tgataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
```

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 122
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 122

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Leu Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  123
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  123
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc caggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 124
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 124

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 125
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 125

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatata atataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 126
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 126

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 127
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 127
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

cttagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 128
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 128

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Leu Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 129
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 129

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtatgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 130
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 130

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Met Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 131
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 131
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtttgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 132
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 132

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Leu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 133
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 133
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt atataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 134
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 134

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Tyr Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 135
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 135
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgca 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 136
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 136

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Ala Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 137
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 137
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

atgtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 138

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 138

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Met Cys Arg Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 139
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 139
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtattg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 140
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 140

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Ile Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 141
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 141
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 142
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 142

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
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Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 143
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 143
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 144
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 144

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 145
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 145

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
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tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 146
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 146

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  147
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  147
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtct tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 148
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 148

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  149
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  149
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggtgtaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 150
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 150

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Cys Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 151
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 151
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagaccga agccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 152
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 152

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Glu Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 153
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 153
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgttg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 154
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 154

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Val Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 155
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 155
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata caataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 156
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 156

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Thr Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 157
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 157
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagtg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 158
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 158

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  159
<211>  1077
<212>  DNA
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 159
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tgaagtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 160
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 160

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Glu Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 161
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 161
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 162

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 162

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Met Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 163
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 163
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gcaggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 164
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 164

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 165
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 165
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

aattgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 166
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 166

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Asn Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 167
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 167
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 168
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 168

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 169
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 169
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 170
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 170

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 171
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 171
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg atataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 172
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 172

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asp Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 173
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 173

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcctgtgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 174
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 174

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 175
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 175
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcatg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 176
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 176

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser His Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 177
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 177

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaggct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 178
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 178

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Arg Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  179
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  179
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata aaataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 180
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 180

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Lys Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 181
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 181
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 182
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 182

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  183
<211>  1077
<212>  DNA
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 183
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagaccca tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 184
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 184

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr His Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 185
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 185
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 186

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 186

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser His Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 187
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 187
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 188
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 188

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys His Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 189
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 189
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 190
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 190

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 191
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 191
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtcatg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 192
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 192

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser His Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 193
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 193
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcatg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 194
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 194

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser His Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  195
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  195
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 196
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 196

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 197
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 197

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 198
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 198

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 199
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 199
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgaggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 200
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 200

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 201
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 201

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 202
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 202

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  203
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  203
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagtttag gccagaccag tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 204
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 204

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Leu Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 205
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 205
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttatg gccagaccga ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 206
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 206

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Glu Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 207
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 207
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccca tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 208
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 208

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr His Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 209
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 209
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 210

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 210

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 211
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 211
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccga ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 212
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 212

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Glu Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 213
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 213
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 214
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 214

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 215
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 215
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 216
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 216

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  217
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  217
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaccct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
```

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgaggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 218
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 218

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  219
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  219
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccga ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 220
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 220

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Glu Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 221
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 221

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 222
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 222

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 223
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 223

```
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 224
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 224

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 225
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 225

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgttgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgaggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 226
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 226

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  227
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  227
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
```

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 228
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 228

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 229
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 229
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgttgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagtgtag gccagaccag tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgaggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 230
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 230

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Val Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 231
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 231
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 232
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 232

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 233
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 233
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgttgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 234

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 234

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Asn Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 235
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 235
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccca tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 236
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 236

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr His Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 237
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 237
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg atataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 238
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 238

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asp Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 239
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 239
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 240
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 240

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 241
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 241
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 242
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 242

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  243
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  243
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 244
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 244

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 245
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 245

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 246
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 246

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 247
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 247
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgcg 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 248
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 248

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Ala Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 249
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 249

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 250
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 250

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  251
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  251
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata ccataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 252
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 252

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Thr Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 253
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 253
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 254
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 254

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 255
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 255
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 256
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 256

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Cys Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 257
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 257
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgcg 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 258

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 258

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Ala Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 259
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 259
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata ccataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 260
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 260

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Thr Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 261
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 261
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataaatct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 262
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 262

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Asn Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 263
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 263
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 264
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 264

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 265
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 265
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 266
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 266

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  267
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  267
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 268
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 268

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 269
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 269

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 270
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 270

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Asp Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 271
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 271

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
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gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 272
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 272

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  273
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  273
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

ccgccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 274
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 274

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Asp Pro Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  275
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  275
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

ccgagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 276
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 276

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Pro Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 277
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 277
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgcg 780

catagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 278
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 278

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Ala His Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 279
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 279
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 280
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 280

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 281
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 281
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 282

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 282

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 283
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 283
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 284
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 284

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Ile Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 285
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 285
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catagtccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 286
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 286

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Ser Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 287
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 287
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 288
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 288

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 289
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 289
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatg atataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 290
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 290

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asp Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  291
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  291
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataaacct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgccgccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 292
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 292

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Pro Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 293
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 293

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 294
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 294

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys His Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 295
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 295

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
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gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 296
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 296

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  297
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  297
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 298
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 298

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  299
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  299
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 300
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 300

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 301
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 301
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata ccatacatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 302
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 302

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Thr Ile His Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  303
<211>  1077
<212>  DNA
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 303
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataaacct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 304
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 304

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Asn Leu Ala Cys Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 305
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 305
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata acataaacct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 306

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 306

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile Asn Leu Ala Cys Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
        355

<210> 307
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 307
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 308
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 308

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 309
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 309
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 310
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 310

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 311
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 311
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 312
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 312

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 313
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 313
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

ccgagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 314
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 314

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp Pro Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  315
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  315
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 316
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 316

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 317
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 317

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgcg 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 318
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 318

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Ala Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 319
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 319
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtatacatct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 320
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 320

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile His Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255

Glu Trp Val Lys His Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
260 265 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 321
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 321
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 322
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 322

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  323
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  323
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 324
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 324

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 325
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 325
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 326
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 326

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Asp Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 327
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 327
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attccggacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 328
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 328

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Pro Asp Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 329
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 329
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 330

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 330

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 331
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 331
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 332
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 332

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 333
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 333
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata ccataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 334
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 334

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Thr Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 335
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 335
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataaacct ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

ccgccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 336
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 336

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Asn Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Pro Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 337
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 337
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 338
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 338

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  339
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  339
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata acatacatct ggcctgcgac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catccgtacg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 340
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 340

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Asn Ile His Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Pro Tyr Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 341
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 341

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 342
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 342

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 343
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 343

```
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggcctgcgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttc tggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catccgccgg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 344
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 344

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Cys Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Leu Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys His Pro Pro Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 345
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 345

```
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag tccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 346
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 346

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Glu Val Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  347
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  347
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtgaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 348
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 348

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 349
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 349
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 350
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 350

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 351
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 351
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 352
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 352

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 353
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 353
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 354

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 354

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
        355

<210> 355
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 355
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 356
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 356

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Met Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 357
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 357
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 358
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 358

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Met Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 359
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 359
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 360
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 360

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Met Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn His Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 361
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 361
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggctgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 362
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 362

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  363
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  363
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 364
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 364

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  365
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  365
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggctgaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 366
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 366

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Leu Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 367
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 367
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 368
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 368

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Met Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn His Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 369
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 369

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 370
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 370

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Met Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  371
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  371
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggctgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 372
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 372

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn His Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 373
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 373
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 374
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 374

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Met Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn His Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 375
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 375
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggatgaag 780

attagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 376
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 376

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Met Lys Ile Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 377
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 377
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gacaatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 378

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 378

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Thr Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 379
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 379
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gagtatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 380
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 380

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ser Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 381
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 381
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gcttatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 382
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 382

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Leu Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 383
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 383
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 384
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 384

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 385
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 385
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctttt tgggccctgg aacagatacg ttcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 386
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 386

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Phe Trp Ala Leu Glu Gln Ile
                165                 170                 175

Arg Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  387
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  387
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 388
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 388

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 389
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 389
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacgtatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 390
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 390

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Arg Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 391
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 391
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagaaagta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 392
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 392

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Lys Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  393
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  393
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatta tgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 394
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 394

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Tyr Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 395
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 395
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggttt gggacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 396
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 396

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Trp Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 397
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 397
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatcg tgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 398
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 398

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Arg Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  399
<211>  1077
<212>  DNA
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 399
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gcgtatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 400
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 400

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Arg Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 401
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 401
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttct tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 402

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 402

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Leu Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 403
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 403
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 404
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 404

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 405
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 405
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 406
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 406

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 407
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 407
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gattatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 408
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 408

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ile Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 409
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 409
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 410
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 410

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  411
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  411
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggttatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 412
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 412

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Val Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 413
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 413

```
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctagt tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 414
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 414

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 415
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 415
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaagag tcagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 416
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 416

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Ser Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  417
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  417
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattggttgg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 418
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 418

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Val Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  419
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  419
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
```

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatagtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 420
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 420

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Ser Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 421
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 421
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gcccaagaaa taagaagtgc tgttgag 1077

<210> 422
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 422

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Gln
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 423
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 423
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaattt tgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 424
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 424

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Phe Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 425
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 425
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

cgtagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 426

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 426

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Arg Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 427
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 427
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 428
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 428

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 429
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 429
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagaccgg tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 430
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 430

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 431
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 431
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcattga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 432
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 432

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ile
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 433
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 433
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattctgt 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 434
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 434

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Cys Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  435
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  435
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatg ttataaatct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 436
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 436

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Val Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 437
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 437

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagaccaa tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 438
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 438

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 439
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 439

```
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 440
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 440

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 441
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 441

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa cttgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 442
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 442

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Leu Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 443
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 443
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggttttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 444
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 444

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 445
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 445
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctagt 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 446
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 446

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Ser Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 447
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 447
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tagtgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 448
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 448

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 449
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 449
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacactt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 450

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 450

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Leu Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 451
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 451
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

atttttcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 452
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 452

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Phe Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 453
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 453
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagaccag tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 454
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 454

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 455
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 455
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

aaaatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 456
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 456

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Lys Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 457
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 457
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcatg 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 458
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 458

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Met Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  459
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  459
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagtga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 460
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 460

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255

Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 461
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 461

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcagggtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 462
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 462

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Arg Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 463
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 463

```
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagaccat tgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 464
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 464

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Ile Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 465
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 465
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 466
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 466

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  467
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  467
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgagtaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 468
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 468

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Ser Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 469
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 469
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgctatt ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 470
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 470

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Tyr Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 471
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 471
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatgt tgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagactgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 472
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 472

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Val Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 473
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 473
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgctttt ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 474

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 474

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Phe Ser
130 135 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 475
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 475
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcgc acacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 476
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 476

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile Ala His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
```

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 477
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 477
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcgtgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 478
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 478

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Arg Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 479
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 479
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctacactg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 480
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 480

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Thr Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 481
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 481

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatg ttataaacct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
```

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 482
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 482

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Val Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  483
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  483
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt gtataaacct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
```

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 484
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 484

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Cys Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 485
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 485

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
```

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 486
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 486

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 487
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 487

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attggttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 488
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 488

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Gly Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 489
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 489
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

ttttatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 490
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 490

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Phe Tyr Ser Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  491
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  491
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa taaagtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 492
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 492

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Lys Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 493
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 493
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttgtg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 494
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 494

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Cys Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  495
<211>  1077
<212>  DNA
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<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 495
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagtaatg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 496
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 496

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Asn Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 497
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 497
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

tttagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 498

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 498

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Phe Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 499
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 499
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccttt ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 500
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 500

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Leu Ser
130 135 140

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Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 501
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 501
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

attagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcatgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 502
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 502

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Ile Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn His Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 503
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 503
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacggtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagctctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaacct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattatagcg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggcttaag 780

tatagttacg gccagaccgg ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

gccggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtgc cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 504
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 504

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Ser Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Leu Lys Tyr Ser Tyr Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Ala Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
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Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 505
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 505
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tctttaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 506
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 506

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Val His Phe Phe Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  507
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  507
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa taatgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 508
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 508

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

```
Ala Met Gln Gly Asn Asn Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  509
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  509
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420
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tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtca tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 510
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 510

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly His Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 511
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 511

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attacagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 512
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 512

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 513
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 513
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcgcagtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 514
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 514

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Ala Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 515
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 515
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

atttgtgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 516
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 516

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Cys Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 517
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 517
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgcg tgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 518
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 518

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Arg Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 519
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 519
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgca agccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtcgggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 520
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 520

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Gln Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 521
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 521
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagttgaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 522

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 522

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160
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Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Leu Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
355

<210> 523
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 523
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgac agccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 524
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 524

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

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Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Thr Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175


Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190


Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 525
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 525
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatata gtataatgct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgat 780

catccggaag gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840

cgcggcgtgc cgggacctac cagccttaac gaagtgcact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 526
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 526

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Ser Ile Met Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Asp His Pro Glu Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Pro Gly Pro Thr Ser
        275                 280                 285

Leu Asn Glu Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 527
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 527
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccgttgac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 528
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 528

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Val Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

```
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
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<210> 529
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 529

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaagac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat      660
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tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 530
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 530

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

```
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  531
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  531
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

cttagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 532
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 532

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Leu Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 533
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 533
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 534
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 534

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
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<210> 535
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 535
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgttga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 536
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 536

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255


Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 537
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 537

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttcat 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 538
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 538

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val His His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  539
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  539
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gcttgacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 540
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 540

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Leu Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 541
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 541
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

caaagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 542
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 542

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Gln Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 543
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 543
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttcaa 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 544
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 544

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Gln His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 545
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 545
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgctgtgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 546

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 546

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
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Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
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Glu Ile Arg Ser Ala Val Glu
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<210> 547
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 547
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgc gtgtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 548
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 548

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

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Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Arg Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
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Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 549
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 549
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 550
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 550

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Gln Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
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Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 551
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 551
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttatagttct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 552
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 552

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Val Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
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Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 553
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 553
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 554
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 554

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
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His Ala Phe Val Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

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Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
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Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  555
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  555
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa      360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt      420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac      480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 556
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 556

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

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Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 557
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 557
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaca atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 558
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 558

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Gln Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 559
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 559

```
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc      300
```

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggtttat 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 560
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 560

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Tyr His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 561
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 561

```
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtccttga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 562
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 562

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Leu
                245                 250                 255


Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 563
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 563
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagtga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 564
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 564

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 565
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 565
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttattacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 566
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 566

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Ile Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205


Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220


Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 567
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 567
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 568
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 568

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 569
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 569
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttggt 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 570

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 570

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Gly His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
355

<210> 571
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 571
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttt gtgagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 572
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 572

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
```

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 573
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 573
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttaaat cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 574
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 574

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Lys Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 575
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 575
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgt ttggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 576
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 576

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Phe Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 577
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 577
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

cgtagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 578
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 578

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

```
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Arg Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
```

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 579
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 579
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttgttacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 580
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 580

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

```
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
```

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 581
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 581
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaat 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 582
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 582

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

```
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
```

```
Glu Trp Val Asn His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 583
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 583
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attacagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 584
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 584

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

```
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
```

```
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 585
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 585

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc      120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
```

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 586
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 586

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

```
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
```

```
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240


Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255


Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270


Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285


Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300


Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320


Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335


Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350


Glu Ile Arg Ser Ala Val Glu
        355


<210>  587
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase CENDH

<400>  587
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc       60
```

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc ttggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 588
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 588

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

```
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
```

```
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Leu Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 589
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 589
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgt gtggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 590
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 590

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
```

```
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Cys Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 591
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 591
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcaaa 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 592
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 592

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160


Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
```

```
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Lys Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350

Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 593
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 593
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

gaaagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 594

<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 594

```
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15


His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30


Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45


Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60


Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80


Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95


Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110


Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125


Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140


Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
```

```
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys Glu Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
```

Glu Ile Arg Ser Ala Val Glu
        355

<210> 595
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 595
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgatgcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 596
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 596

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140

```
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Asp
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
```

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 597
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 597
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttaatt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 598
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 598

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125

```
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Asn Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
```

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 599
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 599
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc aaggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 600
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 600

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110

```
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Gln Gly Pro Thr Ser
        275                 280                 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
```

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 601
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 601
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttgtt 780

catagttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 602
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 602

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95

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Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Val His Ser Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270

Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
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Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 603
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 603
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60

gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180

cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300

gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420

tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540

cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660

tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780

catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900

ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020

ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 604
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 604

Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15

His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30

Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45

Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60

Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80

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Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95

Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110

Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125

Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140

Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160

Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175

Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190

Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205

Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220

Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240

Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255

Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285

Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300

Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320

Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335

Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350

Glu Ile Arg Ser Ala Val Glu
355

<210> 605
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 605
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 606
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 606
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 607
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 607

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 608
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 608
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225   230   235   240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245   250   255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 609
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 609
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcatg 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gcccaggaaa taagaagtgc tgttgag 1077

<210> 610
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 610
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

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        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Met Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Gln
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 611
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 611
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gagcatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 612
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 612
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

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        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ser Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 613
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 613
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gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gaccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 614
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 614
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Thr Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

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        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 615
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 615

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gcgtatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
```

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 616
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 616
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Arg Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
260 265 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser

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        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 617
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 617
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 618
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 618
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
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355

<210> 619
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 619
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gaccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 620
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 620
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu

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    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Thr Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 621
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 621
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 622
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 622
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 623
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 623
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggtgatggac 480

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tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077


<210> 624
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 624
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Val Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
```

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    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 625
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 625

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 626
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 626
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 627
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 627
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 628
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 628

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 629
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 629
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 630
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 630
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

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65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 631
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 631

atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcatg 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gcccaggaaa taagaagtgc tgttgag 1077

<210> 632
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 632
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Met Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp

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145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Gln
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 633
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 633

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gcccaggaaa taagaagtgc tgttgag 1077

<210> 634
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 634
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Gln
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 635
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 635

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 636
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 636
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp

305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 637
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 637
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 638
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 638
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 639

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 639
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttct ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gaccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 640
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 640
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Leu Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

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                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Thr Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 641
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 641
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 642
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 642
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 643
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 643

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 644
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 644
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu

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                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 645
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 645
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 646
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 646
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys

325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 647
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 647
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 648
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 648
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala

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            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 649
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 649
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 650
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 650
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 651
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 651
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 652
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 652
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 653
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 653
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 654
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 654
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu

```
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 655
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 655
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccgg cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 656
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 656
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225   230   235   240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245   250   255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260   265   270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

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            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 657
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 657
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 658
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 658
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
```

```
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 659
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 659
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 660
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 660
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

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        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 661
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 661
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gagcatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 662
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 662
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ser Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 663
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 663
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttct ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 664
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 664
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Leu Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
260 265 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser

```
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 665
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 665
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 666
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 666
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
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355

<210> 667
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 667
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatagcgc gccggaggta acgatcgggg aaacctcaaa catgctcatg 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg tggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 668
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 668
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

```
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Ser Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Met Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Val Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 669
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 669
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 670
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 670
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

```
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 671
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 671
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480

tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 672
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 672
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

```
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 673
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 673

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 674
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 674
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 675
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 675
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccgg cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 676
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 676

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 677
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 677
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 678
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 678
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

```
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 679
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 679

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttga tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcattga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 680
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 680

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Asp Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ile
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 681
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 681

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 682
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 682
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu

225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
260 265 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 683
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 683
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cggctttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagacccc ggccacaatt tatgaagcga tgcagggtaa ttgggtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gcccaggaaa taagaagtgc tgttgag 1077

<210> 684
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 684
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Gly Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Asn Trp Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp

305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Gln
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 685
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 685
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttct ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 686
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 686
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Leu Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 687

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 687
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 688
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 688
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

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                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 689
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 689
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 690
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 690
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 691
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 691

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct gaccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 692
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 692

Met	Ile	Glu	Ser	Lys	Thr	Tyr	Ala	Val	Leu	Gly
1				5				10		
Leu	Gly	Asn	Gly	Gly	His	Ala	Phe	Ala	Ala	Tyr
				20				25		
Leu	Ala	Leu	Lys	Gly	Gln	Arg	Val	Leu	Ala	Trp
			35				40			
Asp	Ile	Asp	Pro	Gln	Arg	Ile	Lys	Glu	Ile	Gln
				50				55		
Asp	Arg	Gly	Ala	Ile	Ile	Ala	Glu	Gly	Pro	Gly
						65				70
Leu	Ala	Gly	Thr	Ala	His	Pro	Asp	Leu	Leu	Thr
							85			
Ser	Asp	Ile	Gly	Leu	Ala	Val	Lys	Asp	Ala	Asp
						100				105
Val	Ile	Leu	Ile	Thr	Val	Pro	Ala	Ile	His	His
					115				120	
Ala	Ser	Ile	Ala	Ala	Lys	Ile	Ala	Ser	Tyr	Ile
				130				135		
Ser	Glu	Gly	Gln	Leu	Ile	Ile	Leu	Asn	Pro	Gly
						145				150
Ala	Thr	Gly	Gly	Ala	Leu	Glu	Phe	Arg	Lys	Ile
							165			
Leu	Arg	Glu	Asn	Gly	Ala	Pro	Glu	Val	Thr	Ile
					180				185	
Gly	Glu	Thr	Ser	Asn	Met	Leu	Phe	Trp	Cys	Arg
						195				200
Ser	Glu	Arg	Pro	Gly	Gln	Val	Thr	Val	Tyr	Phe
					210				215	
Ile	Asn	Leu	Thr	Met	Asp	Phe	Ala	Cys	Leu	Pro
						225				230
Ala	Ala	Lys	Ala	Lys	Trp	Ala	Leu	Glu	Gln	Ile
							245			
Gly	Ser	Val	Leu	Pro	Gln	Tyr	Gln	Ala	Val	Glu
					260				265	
Asn	Val	Leu	His	Thr	Ser	Leu	Thr	Asn	Ile	Glu
						275				280
Ala	Val	Leu	His	Pro	Leu	Pro	Thr	Leu	Leu	Asn
					290				295	
Ala	Ala	Arg	Cys	Glu	Ser	Gly	Thr	Pro	Phe	His
						305				310
Tyr	Tyr	Thr	Glu	Gly	Ile	Thr	Pro	Ser	Val	Gly
							325			
Ala	Leu	Ala	Glu	Lys	Val	Asp	Ala	Glu	Arg	Ile
					340				345	
Ala	Ile	Ala	Lys	Ala	Phe	Asp	Leu	Asn	Val	Pro
						355				360
Ser	Val	Glu								

```
               245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
               325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 693
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 693
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 694
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 694

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
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325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 695
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 695
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 696
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 696
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala

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            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 697
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 697
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 698
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 698
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 699
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 699
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 700
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 700
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 701
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 701

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
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cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 702
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 702
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu

```
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 703
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 703
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttct ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcagcga atggattaag 780
attagtcagg gccagaccgg cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 704
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 704
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Leu Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ser
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Gly Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
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340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 705
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 705
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgt ggggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctaaa tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccaa cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 706
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 706
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

```
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Val Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Lys Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Asn Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 707
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 707
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgatggg ccagcgtgta ctggcttggg acatcgatcc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataaatct ggccatggac 480
tttgcatgtc tcccagcggc aaaagctagc tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atggattaag 780
attagtcagg gccagaccag cgccacaatt tatgaagcga tgcagggtaa tagcgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggtgcact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 708
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 708
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Leu Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Met Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Pro Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

```
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Asn Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Ser Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Ile Lys Ile Ser Gln Gly Gln Thr Ser Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Ser Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 709
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 709
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 710
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 710
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 711
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 711
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 712
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 712

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
```

```
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 713
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 713
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 714
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 714
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
```

355

<210> 715
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 715
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 716
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 716
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

```
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 717
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 717
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 718
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 718
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 719
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 719
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 720
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 720
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

```
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 721
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 721
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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 722
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 722
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
```

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 723
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 723
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 724
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 724

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 725
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 725
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 726
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 726
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

```
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 727
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 727

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 728
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 728

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 729
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 729

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 730
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 730
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 731
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 731

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 732
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 732
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
275 280 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp

305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 733
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 733
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 734
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 734
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 735

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 735
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 736
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 736
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

```
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 737
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 737
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 738
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 738
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile

```
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 739
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 739
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 740
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 740

Met	Ile	Glu	Ser	Lys	Thr	Tyr	Ala	Val	Leu	Gly	Met	Gly	Asn	Gly	Gly
1				5				10						15	
His	Ala	Phe	Ala	Ala	Tyr	Leu	Ala	Leu	Lys	Gly	Gln	Arg	Val	Leu	Ala
			20					25					30		
Trp	Asp	Ile	Asp	Ala	Gln	Arg	Ile	Lys	Glu	Ile	Gln	Asp	Arg	Gly	Ala
		35					40					45			
Ile	Ile	Ala	Glu	Gly	Pro	Gly	Leu	Ala	Gly	Thr	Ala	His	Pro	Asp	Leu
	50					55					60				
Val	Thr	Ser	Asp	Ile	Gly	Leu	Ala	Val	Lys	Asp	Ala	Asp	Val	Ile	Leu
65					70					75					80
Ile	Val	Val	Pro	Ala	Ile	His	His	Ala	Ser	Ile	Ala	Ala	Lys	Ile	Ala
				85					90					95	
Ser	Tyr	Ile	Ser	Glu	Gly	Gln	Leu	Ile	Ile	Leu	Asn	Pro	Gly	Ala	Thr
			100					105					110		
Gly	Gly	Ala	Leu	Glu	Phe	Arg	Lys	Ile	Leu	Arg	Glu	Asn	Gly	Ala	Pro
		115					120					125			
Glu	Val	Thr	Ile	Gly	Glu	Thr	Ser	Asn	Met	Leu	Phe	Trp	Cys	Arg	Ser
	130					135					140				
Glu	Arg	Pro	Gly	Gln	Val	Thr	Val	Tyr	Phe	Ile	Thr	Leu	Ala	Met	Asp
145					150					155					160
Phe	Ala	Cys	Leu	Pro	Ala	Ala	Lys	Ala	Gly	Trp	Ala	Leu	Glu	Gln	Ile
				165					170					175	
Gly	Ser	Val	Leu	Pro	Gln	Tyr	Gln	Ala	Val	Glu	Asn	Val	Leu	His	Thr
			180					185					190		
Ser	Leu	Thr	Asn	Ile	Glu	Ala	Val	Ile	His	Pro	Leu	Pro	Thr	Leu	Leu
		195					200					205			
Asn	Ala	Ala	Arg	Cys	Glu	Ser	Gly	Thr	Pro	Phe	His	Tyr	Tyr	Thr	Glu
	210					215					220				
Gly	Ile	Thr	Pro	Ser	Val	Gly	Ala	Leu	Cys	Glu	Lys	Val	Asp	Ala	Glu
225					230					235					240
Arg	Ile	Ala	Ile	Ala	Lys	Ala	Phe	Asp	Leu	Asn	Val	Pro	Ser	Val	Glu

```
               245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 741
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 741
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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 742
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 742

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
```

```
               325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 743
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 743
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 744
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 744
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
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```
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 745
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 745
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 746
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 746
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 747
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 747
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 748
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 748
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 749
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 749
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 750
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 750
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
245 250 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu

```
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 751
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 751

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 752
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 752
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225   230   235   240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245   250   255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 753
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 753
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 754
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 754
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

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        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 755
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 755
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 756
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 756
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

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        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 757
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 757
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 758
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 758
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 759
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 759
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 760
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 760

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
```

```
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 761
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 761
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 762
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 762
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
```

355

<210> 763
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 763
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcga tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 764
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 764
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

```
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 765
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 765
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 766
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 766
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 767
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 767
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 768
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 768
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

```
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 769
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 769

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 770
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 770
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 771
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 771

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 772
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 772

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 773
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 773
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 774
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 774
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

```
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 775
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 775

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 776
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 776

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 777
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 777

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 778
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 778
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 779
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 779

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 780
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 780
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
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305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 781
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 781
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gtggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 782
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 782
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 783

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 783
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 784
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 784
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

```
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 785
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 785
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 786
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 786
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile

```
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 787
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 787
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 788
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 788

Met	Ile	Glu	Ser	Lys	Thr	Tyr	Ala	Val	Leu	Gly	Met	Gly	Asn	Gly	Gly
1				5				10					15		
His	Ala	Phe	Ala	Ala	Tyr	Leu	Ala	Leu	Lys	Gly	Gln	Arg	Val	Leu	Ala
			20					25				30			
Trp	Asp	Ile	Asp	Ala	Gln	Arg	Ile	Lys	Glu	Ile	Gln	Asp	Arg	Gly	Ala
		35					40					45			
Ile	Ile	Ala	Glu	Gly	Pro	Gly	Leu	Ala	Gly	Thr	Ala	His	Pro	Asp	Leu
	50					55					60				
Val	Thr	Ser	Asp	Ile	Gly	Leu	Ala	Val	Lys	Asp	Ala	Asp	Val	Ile	Leu
65					70					75					80
Ile	Val	Val	Pro	Ala	Ile	His	His	Ala	Ser	Ile	Ala	Ala	Lys	Ile	Ala
				85					90					95	
Ser	Tyr	Ile	Ser	Glu	Gly	Gln	Leu	Ile	Ile	Leu	Asn	Pro	Gly	Ala	Thr
			100					105					110		
Gly	Gly	Ala	Leu	Glu	Phe	Arg	Lys	Ile	Leu	Arg	Glu	Asn	Gly	Ala	Pro
		115					120					125			
Glu	Val	Thr	Ile	Gly	Glu	Thr	Ser	Asn	Met	Leu	Phe	Trp	Cys	Arg	Ser
	130					135					140				
Glu	Arg	Pro	Gly	Gln	Val	Thr	Val	Tyr	Phe	Ile	Thr	Leu	Ala	Gln	Asp
145					150					155					160
Phe	Ala	Cys	Leu	Pro	Ala	Ala	Lys	Ala	Gly	Trp	Ala	Leu	Glu	Gln	Ile
				165					170					175	
Gly	Ser	Val	Leu	Pro	Gln	Tyr	Gln	Ala	Val	Glu	Asn	Val	Leu	His	Thr
			180					185					190		
Ser	Leu	Thr	Asn	Ile	Glu	Ala	Val	Leu	His	Pro	Leu	Pro	Thr	Leu	Leu
		195					200					205			
Asn	Ala	Ala	Arg	Cys	Glu	Ser	Gly	Thr	Pro	Phe	His	Tyr	Tyr	Thr	Glu
	210					215					220				
Gly	Ile	Thr	Pro	Ser	Val	Gly	Ala	Leu	Cys	Glu	Lys	Val	Asp	Ala	Glu
225					230					235					240
Arg	Ile	Ala	Ile	Ala	Lys	Ala	Phe	Asp	Leu	Asn	Val	Pro	Ser	Val	Ala

```
               245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 789
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 789
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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 790
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 790

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
```

```
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 791
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 791
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 792
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 792
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                   10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
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```
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 793
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 793
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 794
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 794
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 795
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 795
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcatgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 796
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 796
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

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            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Met His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 797
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 797
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 798
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 798
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 799
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 799
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 800
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 800
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225   230   235   240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245   250   255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 801
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 801
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 802
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 802
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

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        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 803
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 803
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 804
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 804
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

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        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 805
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 805
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 806
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 806
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 807
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 807

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
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gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 808
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 808

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
```

```
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 809
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 809
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 810
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 810
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
```

355

<210> 811
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 811
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 812
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 812
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

```
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 813
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 813
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 814
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 814
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

```
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 815
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 815
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 816
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 816
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

```
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 817
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 817

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 818
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 818
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245 250 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 819
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 819
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 820
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 820

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 821
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 821
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 822
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 822
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

```
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 823
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 823

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 824
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 824

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 825
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 825
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 826
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 826
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 827
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 827

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 828
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 828
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
```

305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 829
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 829
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 830
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 830
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly

CX2-136USP2A_ST25

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 831

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 831
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 832
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 832
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

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                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 833
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 833
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 834
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 834
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 835
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 835
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720

cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 836
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 836

Met	Ile	Glu	Ser	Lys	Thr	Tyr	Ala	Val	Leu	Gly	Met	Gly	Asn	Gly	Gly
1				5				10						15	
His	Ala	Phe	Ala	Ala	Tyr	Leu	Ala	Leu	Lys	Gly	Gln	Arg	Val	Leu	Ala
			20					25					30		
Trp	Asp	Ile	Asp	Ala	Gln	Arg	Ile	Lys	Glu	Ile	Gln	Asp	Arg	Gly	Ala
		35					40					45			
Ile	Ile	Ala	Glu	Gly	Pro	Gly	Leu	Ala	Gly	Thr	Ala	His	Pro	Asp	Leu
	50					55					60				
Val	Thr	Ser	Asp	Ile	Gly	Leu	Ala	Val	Lys	Asp	Ala	Asp	Val	Ile	Leu
65					70					75					80
Ile	Thr	Val	Pro	Ala	Ile	His	His	Ala	Ser	Ile	Ala	Ala	Lys	Ile	Ala
				85					90					95	
Ser	Tyr	Ile	Ser	Glu	Gly	Gln	Leu	Ile	Ile	Leu	Asn	Pro	Gly	Ala	Thr
			100					105					110		
Gly	Gly	Ala	Leu	Glu	Phe	Arg	Lys	Ile	Leu	Arg	Glu	Asn	Gly	Ala	Pro
		115					120					125			
Glu	Val	Thr	Ile	Gly	Glu	Thr	Ser	Asn	Met	Leu	Phe	Trp	Cys	Arg	Ser
	130					135					140				
Glu	Arg	Pro	Gly	Gln	Val	Thr	Val	Phe	Phe	Ile	Thr	Leu	Ala	Met	Asp
145					150					155					160
Phe	Ala	Cys	Leu	Pro	Ala	Ala	Lys	Ala	Gly	Trp	Ala	Leu	Glu	Gln	Ile
				165					170					175	
Gly	Ser	Val	Leu	Pro	Gln	Tyr	Gln	Ala	Val	Glu	Asn	Val	Leu	His	Thr
			180					185					190		
Ser	Leu	Thr	Asn	Ile	Glu	Ala	Val	Ile	His	Pro	Leu	Pro	Thr	Leu	Leu
		195					200					205			
Asn	Ala	Ala	Arg	Cys	Glu	Ser	Gly	Thr	Pro	Phe	His	Tyr	Tyr	Thr	Glu
	210					215					220				
Gly	Ile	Thr	Pro	Ser	Val	Gly	Ala	Leu	Cys	Glu	Lys	Val	Asp	Ala	Glu
225					230					235					240
Arg	Cys	Ala	Ile	Ala	Lys	Ala	Phe	Asp	Leu	Asn	Val	Pro	Ser	Val	Ala

```
               245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 837
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 837

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 838
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 838

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
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325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 839
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 839
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 840
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 840
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala

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            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 841
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 841
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 842
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 842
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 843
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 843
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 844
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 844
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 845
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 845
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 846
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 846
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
245 250 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu

```
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 847
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 847

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 848
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 848
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
```

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 849
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 849
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 850
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 850
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

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        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 851
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 851
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 852
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 852
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

```
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 853
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 853
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 854
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 854
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 855
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 855
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 856
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 856

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
```

```
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 857
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 857
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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 858
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 858
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
```

355

<210> 859
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 859
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 860
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 860
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

```
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 861
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 861
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 862
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 862
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

```
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 863
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 863
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 864
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 864
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

```
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 865
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 865

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 866
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 866
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245 250 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 867
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 867
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 868
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 868

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 869
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 869
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 870
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 870
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

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65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 871
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 871

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggc ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 872
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 872

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 873
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 873

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 874
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 874
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 875
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 875

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 876
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 876

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
```

305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 877
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 877
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 878
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 878
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly

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1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 879

<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 879
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggggcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 880
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 880
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala

```
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Gly Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 881
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 881
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 882
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 882
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 883
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 883
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 884
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 884

Met	Ile	Glu	Ser	Lys	Thr	Tyr	Ala	Val	Leu	Gly	Met	Gly	Asn	Gly	Gly
1				5				10					15		
His	Ala	Phe	Ala	Ala	Tyr	Leu	Ala	Leu	Lys	Gly	Gln	Arg	Val	Leu	Ala
			20					25					30		
Trp	Asp	Ile	Asp	Ala	Gln	Arg	Ile	Lys	Glu	Ile	Gln	Asp	Arg	Gly	Ala
		35					40					45			
Ile	Ile	Ala	Glu	Gly	Pro	Gly	Leu	Ala	Gly	Thr	Ala	His	Pro	Asp	Leu
	50					55					60				
Val	Thr	Ser	Asp	Ile	Gly	Leu	Ala	Val	Lys	Asp	Ala	Asp	Val	Ile	Leu
65					70					75					80
Ile	Val	Val	Pro	Ala	Ile	His	His	Ala	Ser	Ile	Ala	Ala	Lys	Ile	Ala
				85					90					95	
Ser	Tyr	Ile	Ser	Glu	Gly	Gln	Leu	Ile	Ile	Leu	Asn	Pro	Gly	Ala	Thr
			100					105					110		
Gly	Gly	Ala	Leu	Glu	Phe	Arg	Lys	Ile	Leu	Arg	Glu	Asn	Gly	Ala	Pro
		115					120					125			
Glu	Val	Thr	Ile	Gly	Glu	Thr	Ser	Asn	Met	Leu	Phe	Trp	Cys	Arg	Ser
	130					135					140				
Glu	Arg	Pro	Gly	Gln	Val	Thr	Val	Tyr	Phe	Ile	Thr	Leu	Ala	Gln	Asp
145					150					155					160
Phe	Ala	Cys	Leu	Pro	Ala	Ala	Lys	Ala	Gly	Trp	Ala	Leu	Glu	Gln	Ile
				165					170					175	
Gly	Ser	Val	Leu	Pro	Gln	Tyr	Gln	Ala	Val	Glu	Asn	Val	Leu	His	Thr
			180					185					190		
Ser	Leu	Thr	Asn	Ile	Glu	Ala	Val	Ile	His	Pro	Leu	Pro	Thr	Leu	Leu
		195					200					205			
Asn	Ala	Ala	Arg	Cys	Glu	Ser	Gly	Thr	Pro	Phe	His	Tyr	Tyr	Thr	Glu
	210					215					220				
Gly	Ile	Thr	Pro	Ser	Val	Gly	Ala	Leu	Ala	Glu	Lys	Val	Asp	Ala	Glu
225					230					235					240
Arg	Cys	Ala	Ile	Ala	Lys	Ala	Phe	Asp	Leu	Asn	Val	Pro	Ser	Val	Ala

```
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 885
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 885
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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 886
<211> 359

<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 886

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
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325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 887
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 887
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 888
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 888
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala

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            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 889
<211> 1077
<212> DNA

<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 889
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 890
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 890
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr

```
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 891
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 891
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 892
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 892
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr

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            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 893
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 893
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840

cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 894
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 894
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
245 250 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 895
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 895

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 896
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 896
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115   120   125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225   230   235   240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245   250   255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 897
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 897
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 898
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 898
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala

```
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 899
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 899
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 900
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 900
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65   70   75   80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro

```
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 901
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 901
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 902
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 902
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu

```
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 903
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 903

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaag 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
```

gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 904
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 904

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Lys Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
```

```
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 905
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 905
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 906
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 906
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
```

355

<210> 907
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 907
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtagaat ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 908
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 908
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu

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    50                  55                  60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Glu Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 909
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 909
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 910
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 910
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 911
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 911
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 912
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 912
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

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    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 913
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 913

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatttt ttataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaag 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 914
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 914
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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Phe Phe Ile Thr Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Lys His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
```

```
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 915
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 915
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgaaga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<210> 916
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 916

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Glu
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 917
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 917
atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 918
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 918
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu

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65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Val
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 919
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 919

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtgc atggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 920
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 920

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Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1               5                  10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65                  70                  75                  80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
```

```
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225                 230                 235                 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val His Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 921
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 921

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
```

attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgctgcgcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
caggtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 922
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 922
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu Lys Val Asp Ala Glu

```
225                 230                 235                 240
Arg Cys Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245                 250                 255
Glu Trp Val Asn Gln Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 923
<211> 1077
<212> DNA
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 923

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atgatcgagt caaaaacata cgccgttttg ggaatgggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttgtgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attaccgtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
tggtgccgct ccgagagacc aggacaggtt acggtatatt ttataacact ggcccaggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
attcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttt gcgagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgcgga atgggttaac 780
catgtttgtg gccagacccc ggccacaatt tatgaagcga tgcagggtct gcctgtgctg 840
cgcggcgtga gcggacctac cagccttaac acggaacact tcagcaacga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
```

<210> 924
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 924
Met Ile Glu Ser Lys Thr Tyr Ala Val Leu Gly Met Gly Asn Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50 55 60
Val Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ala Asp Val Ile Leu
65 70 75 80
Ile Thr Val Pro Ala Ile His His Ala Ser Ile Ala Ala Lys Ile Ala
                85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115 120 125
Glu Val Thr Ile Gly Glu Thr Ser Asn Met Leu Phe Trp Cys Arg Ser
    130 135 140
Glu Arg Pro Gly Gln Val Thr Val Tyr Phe Ile Thr Leu Ala Gln Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Ile His Pro Leu Pro Thr Leu Leu
        195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Cys Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Lys Ala Phe Asp Leu Asn Val Pro Ser Val Ala
                245 250 255
Glu Trp Val Asn His Val Cys Gly Gln Thr Pro Ala Thr Ile Tyr Glu
            260 265 270
Ala Met Gln Gly Leu Pro Val Leu Arg Gly Val Ser Gly Pro Thr Ser
        275 280 285
Leu Asn Thr Glu His Phe Ser Asn Asp Val Ser Thr Gly Leu Val Pro
    290 295 300
Leu Ser Glu Leu Gly Arg Val Val Asn Val Pro Thr Pro Leu Ile Asp

```
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
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