SEQUENCE LISTING

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<120> ENGINEERED IMINE REDUCTASES AND METHODS FOR THE REDUCTIVE AMINATION OF KETONE AND AMINE COMPOUNDS

<130> CX2-120US2

<150> 61/646,100
<151> 2012-05-11

<160> 750

<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
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gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat 840
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

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

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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 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 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
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
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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
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acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac 480
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cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt ggcggctgta 600

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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggtacaag      780
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ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
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

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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Ala 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
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
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Gly Ile Arg Ser Ala Val Glu
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<210>  5
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<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
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acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gcatgctgta 600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<210> 6
<211> 359
<212> PRT
<213> Artificial Sequence

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

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

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                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
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>  7
<211>  1077
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Engineered variant of opine dehydrogenase 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 cgataattgg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
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<210>  8
<211>  359
<212>  PRT
<213>  Artificial Sequence

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

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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 Asn Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
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            100                 105                 110
Gly Gly Ala 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 Ile 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
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> 9
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 9

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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
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acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac      480
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gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
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<210> 10
<211> 359
<212> PRT
<213> Artificial Sequence

<220>
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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
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 Ala Thr
            100   105   110
Gly Gly Ala 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 Ile 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
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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<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

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acatgccgct ccgagagacc aggacaggtt acggtaaatg cgatagttgg cgccatggac      480
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ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
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<210> 12
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 12

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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Val 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
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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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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggacgaag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat 840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

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

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

<400> 14
Met Ile Glu Ser Lys 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
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 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 Thr 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
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
        355
```

<210> 15
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 15

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gcctgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Pro 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
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
        355
```

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

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

<400> 17

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataacggg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
```

<210> 18
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 18
Met Ile Glu Ser Lys 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
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 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120

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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 cgatacaggg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag         1077
```

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

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

<400> 20

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Gln 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
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
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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
Gly 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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataagtgg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Ser 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
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
        355
```

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

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

<400> 23

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggagtaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 24
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 24

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Ser 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
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
```

gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Met 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataggtgg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Gly 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
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
        355
```

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

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

<400> 29

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 aaaccggtag tatgctcttt      420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 30
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 30

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Gly 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
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
        355
```

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

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

<400> 31

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag         1077
```

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

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

<400> 32

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 His 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
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
        355
```

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

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

<400> 33

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
cttcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggtacaag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat 840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggattaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu 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 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 Ile 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
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
        355
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<210> 39
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 39

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gagtgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 40
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 40
Met Ile Glu Ser Lys 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
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 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 Ser 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480

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tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggctgaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat      840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Leu 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
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
        355
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<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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120

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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggagaag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgcttat 840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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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 Glu 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
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
        355
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<210> 45
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 45

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc      300
gagggtcagt tgattatcct taaccctggg agtacgggtg gagcgctgga attccggaaa      360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt      420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 46
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 46

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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 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 Ser Thr
            100                 105                 110
Gly Gly Ala 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
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
        355
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<210> 47
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 47

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgcgcactt tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Leu Asn Thr Arg Thr 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cagacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Gln Thr
100 105 110
Gly Gly Ala 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acgcgccagt tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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            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
Leu Asn Thr Arg Gln 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
        355
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<210> 53
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 53

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgcgcttgt tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 54
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 54

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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 Ser 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 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 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
Leu Asn Thr Arg Leu 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
        355


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

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

<400>  55
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
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cgcggcattg cgggacctat taaccttaac acgatttact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Leu Asn Thr Ile 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
355

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

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

<400> 57
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acggtgtact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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

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        275                 280                 285
Leu Asn Thr Val 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
        355
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<210> 59
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 59

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgcgcgttt tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 60
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 60

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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
Leu Asn Thr Arg Val 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
        355
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<210> 61
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 61

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgacttact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<210> 62
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 62
Met Ile Glu Ser Lys 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
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 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
Leu Asn Thr Thr 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600

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 acgcgccatt tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 64
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 64
Met Ile Glu Ser Lys 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
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 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
Leu Asn Thr Arg 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acggggtact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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                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
Leu Asn Thr Gly 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgccgtact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
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            100                 105                 110
Gly Gly Ala 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
Leu Asn Thr Pro 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
        355
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<210> 69
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 69

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgtgttact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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
Leu Asn Thr Cys 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc   120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acgtattact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Leu Asn Thr Tyr 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

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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acgtcgtact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Leu Asn Thr Ser 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgcgcattt tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag         1077
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<210> 76
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 76

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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
Leu Asn Thr Arg Ile 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
        355
```

<210> 77
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 77

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc      300
gagggtcagt tgattatcct taaccctggg atgacgggtg gagcgctgga attccggaaa      360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt      420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Met Thr
100 105 110
Gly Gly Ala 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
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
355

<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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120

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 cgataaaagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta 600
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 acgcgcaagt tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Leu Asn Thr Arg Lys 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
        355
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<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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gaacgctgta      600
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 acgcgcaatt tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
```

<210> 82
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 82

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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
Leu Asn Thr Arg Asn 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
        355
```

<210> 83
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 83

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatcc gaacgctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
```

<210> 84
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 84

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Pro 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
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
        355
```

<210> 85
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 85

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt ggaggctgta      600
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
```

gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Glu 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg atgacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt gcatgctgta 600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Met Thr
100 105 110
Gly Gly Ala 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 Val His 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 Met Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatcc ccatgctgta 600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acgcctcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Pro His 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 His Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285
Leu Asn Thr Pro 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
        355
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<210> 91
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 91

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc      300
gagggtcagt tgattatcct taaccctggg atgacgggtg gagcgctgga attccggaaa      360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaaccggcag tatgctcttt      420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgatatcagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat ccatgctgta      600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag         1077
```

<210> 92
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 92

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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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Met Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Gly Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Ser 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 His 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
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
        355
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<210> 93
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 93

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acgcgctact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Ile Glu 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 Met Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
275 280 285
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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                245                 250                 255
Glu Trp His Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct      180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg      240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc      300
gagggtcagt tgattatcct taaccctggg atgacgggtg gagcgctgga attccggaaa      360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaaccggcag tatgctcttt      420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataaaagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatgt ccatgctgta      600
atgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg      840
cgcggcattg cgggacctat taaccttaac acgagtcact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Met Thr
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            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Glu Asn Gly Ala Pro
        115                 120                 125
Glu Val Thr Ile Gly Glu Thr Gly 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 His 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 Met Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285
Leu Asn Thr Ser 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
        355
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<210> 99
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 99

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc       60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc      120
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 cgatagtagg cgccatggac      480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt      540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatcc tgaagctgta      600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa      660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa      720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggatgaag      780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg      840
cgcggcattg cgggacctat taaccttaac acgacttact tcttcgagga tgtaagcacc      900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat      960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc     1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag        1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Val 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 Pro Glu 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 Met Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
275 280 285
Leu Asn Thr Thr 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
355

<210> 101
<211> 1197
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized D-octopine dehydrogenase from Pecten maximus
(great scallop) [OpDH]

<400> 101
atgacagtga aagtatgcgt ttgcggaggt gggaatggcg cccatacttt atcagggctt 60
gccgccagcc gcgatggggt tgaagtgcgt gtcttgacac tttttgccga tgaagccgaa 120
cgctggacta aagcactggg agcagatgag ttgaccgtga tcgtgaatga gaaagacggc 180
acccagactg aagtgaaatc gcgccccaag gtcatcacta aagatcctga aatcgctatt 240
tcgggggcag acgtggtgat tcttacggtt ccagcctttg cacacgaggg ctattttcag 300

gcgatggcac catatgttca agactcggcg ttaattgtgg gtttaccatc ccaggccgga 360
tttgaatttc aatgtcggga cattttgggt gataaggcgg ccgccgtttc catgatgagc 420
ttcgaaactt tgccttgggc ctgcagaatc aaagaatttg ggcgcaaagt tgaggtctta 480
ggtacgaaaa gcgtactggc tgctagtctt atcaaaggga ctgcgaaaac tgtcgatcct 540
ctgtctacgt tacagatgct tcatggggct gaaccagtgt tccgcttagc gaagcatttc 600
ctggagatgc tgattatgag ttactcattc gtccacccgg ccatattatt tggtcgctgg 660
ggtagttggg atggtaagcc tgtgccggaa gctccgctgt tttaccaggg gatagaccag 720
gccacagcgg atatgctgac agcatgctcg aatgaatgca aagatgtggc gaatgctatt 780
atggccgcgt gtccaggcaa cgatctctcc gacgttaagg acatctacca gtggtacctt 840
gagtactacc atgaagatat acaggacgac catgatctgt accatgccat cacaacgaac 900
aaatcgtaca agggattggt ccacccggtc aaggcggtag atggtggtgt ggccccggat 960
ttcggaaacc gctacctgac agaggacatt ccgatgggca tgattgtatt taaaggcgtc 1020
gccatcgcag caggcgtggc aatacccagc aacgataaac tcatcatgtg ggctcaagag 1080
aaaatcggca aggagtacct cgtggacggt gcactcacgg ggaaagatgt cgcgacgacg 1140
cgttgtccgc agcgctatgg ctttaatacg ctggatgcta ttctgactgg caagaaa 1197

<210> 102
<211> 399
<212> PRT
<213> Pecten maximus

<400> 102
Met Thr Val Lys Val Cys Val Cys Gly Gly Gly Asn Gly Ala His Thr
1 5 10 15
Leu Ser Gly Leu Ala Ala Ser Arg Asp Gly Val Glu Val Arg Val Leu
20 25 30
Thr Leu Phe Ala Asp Glu Ala Glu Arg Trp Thr Lys Ala Leu Gly Ala
35 40 45
Asp Glu Leu Thr Val Ile Val Asn Glu Lys Asp Gly Thr Gln Thr Glu
50 55 60
Val Lys Ser Arg Pro Lys Val Ile Thr Lys Asp Pro Glu Ile Ala Ile
65 70 75 80
Ser Gly Ala Asp Val Val Ile Leu Thr Val Pro Ala Phe Ala His Glu
85 90 95
Gly Tyr Phe Gln Ala Met Ala Pro Tyr Val Gln Asp Ser Ala Leu Ile
100 105 110
Val Gly Leu Pro Ser Gln Ala Gly Phe Glu Phe Gln Cys Arg Asp Ile
115 120 125
Leu Gly Asp Lys Ala Ala Ala Val Ser Met Met Ser Phe Glu Thr Leu
130 135 140
Pro Trp Ala Cys Arg Ile Lys Glu Phe Gly Arg Lys Val Glu Val Leu
145 150 155 160
Gly Thr Lys Ser Val Leu Ala Ala Ser Leu Ile Lys Gly Thr Ala Lys
165 170 175
Thr Val Asp Pro Leu Ser Thr Leu Gln Met Leu His Gly Ala Glu Pro
180 185 190
Val Phe Arg Leu Ala Lys His Phe Leu Glu Met Leu Ile Met Ser Tyr
195 200 205
Ser Phe Val His Pro Ala Ile Leu Phe Gly Arg Trp Gly Ser Trp Asp
210 215 220
Gly Lys Pro Val Pro Glu Ala Pro Leu Phe Tyr Gln Gly Ile Asp Gln
225 230 235 240
Ala Thr Ala Asp Met Leu Thr Ala Cys Ser Asn Glu Cys Lys Asp Val
245 250 255
Ala Asn Ala Ile Met Ala Ala Cys Pro Gly Asn Asp Leu Ser Asp Val
260 265 270
Lys Asp Ile Tyr Gln Trp Tyr Leu Glu Tyr Tyr His Glu Asp Ile Gln
275 280 285
Asp Asp His Asp Leu Tyr His Ala Ile Thr Thr Asn Lys Ser Tyr Lys
290 295 300
Gly Leu Val His Pro Val Lys Ala Val Asp Gly Gly Val Ala Pro Asp
305 310 315 320
Phe Gly Asn Arg Tyr Leu Thr Glu Asp Ile Pro Met Gly Met Ile Val
325 330 335
Phe Lys Gly Val Ala Ile Ala Ala Gly Val Ala Ile Pro Ser Asn Asp
340 345 350
Lys Leu Ile Met Trp Ala Gln Glu Lys Ile Gly Lys Glu Tyr Leu Val

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        355                 360                 365
Asp Gly Ala Leu Thr Gly Lys Asp Val Ala Thr Thr Arg Cys Pro Gln
    370                 375                 380
Arg Tyr Gly Phe Asn Thr Leu Asp Ala Ile Leu Thr Gly Lys Lys
385                 390                 395
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<210> 103
<211> 939
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized Ornithine synthase from Lactococcus lactis K1 [CEOS]

<400> 103

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atgaaaattg gactggtcaa agcaaacttc cccggagaac ggcgcgttcc tttgcttccg       60
aaagatatca aggatttcaa aaacgagata ttagtagaag agggcttcgg taaatttctg      120
gatattgacg atcaggagta ttcagacaag ggttgtcata tcttaagtcg ggccgaagtt      180
ttcgcggaat cagaagctat cttctcgctg aaattgattc aaccaacaga ttactatcat      240
cttcgtgaag gacagatgat tattgggtgg actcatccat tcgggagtgg ccagtcgttt      300
atgaaagaac aggcgctgcc taagaagttg atcgttgtgg atcttgattc caattcgccg      360
tgcatatatt atgaaaacga gatttttgaa agtggcatcc ctaaagggtt gctctataaa      420
aattcttttt atgcgggtta cgccggtgtt ctggatgctt tgttacagta tgggctcata      480
cctactgagg agacaaaaat cgcaatttta gggtctggga acgttgcaca gggtgcattc      540
tcgtctatct ctaaatattc gagtaacatt cggatgtatt atagaaagac catgtcaatc      600
tttaaggaga attatacgaa gtacgatata atcatcaacg gtatcgaaat tggaaaagac      660
gacgatccca tcttgtcatt ctctgaacaa aagtccctca aaaagggaac actgattata      720
gatgtagccg ccgacgctgg caatacgatc gaggggagtc actttacatc tatagatgca      780
ccaatatatg aaaacgccgg gaagtattac tatgtcgtac cgaatacgcc tagtctgatc      840
tacagaaatg ttagtcaaga actgtcaaaa attctgagtg aaaacatttt tcgcaaggac      900
tgttcacggt ttatcgaaaa agtaaaacct ctgaacaaa                             939
```

<210> 104
<211> 313
<212> PRT
<213> Lactococcus lactis K1

<400> 104

```
Met Lys Ile Gly Leu Val Lys Ala Asn Phe Pro Gly Glu Arg Arg Val
1               5                  10                  15
Pro Leu Leu Pro Lys Asp Ile Lys Asp Phe Lys Asn Glu Ile Leu Val
            20                  25                  30
Glu Glu Gly Phe Gly Lys Phe Leu Asp Ile Asp Asp Gln Glu Tyr Ser
        35                  40                  45
Asp Lys Gly Cys His Ile Leu Ser Arg Ala Glu Val Phe Ala Glu Ser
    50                  55                  60
Glu Ala Ile Phe Ser Leu Lys Leu Ile Gln Pro Thr Asp Tyr Tyr His
65                  70                  75                  80
Leu Arg Glu Gly Gln Met Ile Ile Gly Trp Thr His Pro Phe Gly Ser
                85                  90                  95
Gly Gln Ser Phe Met Lys Glu Gln Ala Leu Pro Lys Lys Leu Ile Val
            100                 105                 110
Val Asp Leu Asp Ser Asn Ser Pro Cys Ile Tyr Tyr Glu Asn Glu Ile
        115                 120                 125
Phe Glu Ser Gly Ile Pro Lys Gly Leu Leu Tyr Lys Asn Ser Phe Tyr
    130                 135                 140
Ala Gly Tyr Ala Gly Val Leu Asp Ala Leu Leu Gln Tyr Gly Leu Ile
145                 150                 155                 160
Pro Thr Glu Glu Thr Lys Ile Ala Ile Leu Gly Ser Gly Asn Val Ala
                165                 170                 175
Gln Gly Ala Phe Ser Ser Ile Ser Lys Tyr Ser Ser Asn Ile Arg Met
            180                 185                 190
Tyr Tyr Arg Lys Thr Met Ser Ile Phe Lys Glu Asn Tyr Thr Lys Tyr
        195                 200                 205
Asp Ile Ile Ile Asn Gly Ile Glu Ile Gly Lys Asp Asp Asp Pro Ile
```

```
    210                 215                 220
Leu Ser Phe Ser Glu Gln Lys Ser Leu Lys Lys Gly Thr Leu Ile Ile
225                 230                 235                 240
Asp Val Ala Ala Asp Ala Gly Asn Thr Ile Glu Gly Ser His Phe Thr
                245                 250                 255
Ser Ile Asp Ala Pro Ile Tyr Glu Asn Ala Gly Lys Tyr Tyr Tyr Val
            260                 265                 270
Val Pro Asn Thr Pro Ser Leu Ile Tyr Arg Asn Val Ser Gln Glu Leu
        275                 280                 285
Ser Lys Ile Leu Ser Glu Asn Ile Phe Arg Lys Asp Cys Ser Arg Phe
    290                 295                 300
Ile Glu Lys Val Lys Pro Leu Asn Lys
305                 310
```

<210> 105
<211> 1023
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized N-methyl-L-amino acid dehydrogenase from Pseudomonas putida [NMDH]

<400> 105

```
atgagcgcac catccacgag caccgtagtg cgcgtcccct ttacagaact gcaatcttta       60
ctgcaagcca tcttccagcg tcacgggtgt agcgaagctg tagctcgtgt gcttgcacat      120
aactgcgcaa gtgcacagcg cgatggcgcg catagtcacg gcgtgtttcg tatgccgggc      180
tatgtctcga ctttagcaag cggttgggtt gatggtcagg ccactccaca ggtgagtgat      240
gttgcagcgg gctatgttcg tgttgacgca gcaggtggct ttgcacagcc agcacttgca      300
gcagcacgtg aactgctggt cgcgaaggca cgtagtgcag gtattgcagt tctggccatc      360
cacaacagcc accatttcgc agcactgtgg ccagatgttg aaccgtttgc agaagaaggt      420
ctggttgcac tgagcgttgt caacagcatg acttgcgttg ttccacatgg tgcacgtaaa      480
ccgctgttcg gcaccaatcc cattgcattt gcagcaccgt gcgcagagca tgatccgatc      540
gtgtttgaca tggccacgag cgcaatggca catggtgatg tgcagattgc agcacgtgca      600
ggtcagcagc tgccggaagg tatgggtgtt gatgcagatg gtcagccaac tactgatccg      660
aaggcgattc tggaaggtgg tgcgttgtta ccatttggcg gtcataaggg ttcggcgttg      720
agcatgatgg tcgagctgtt agcagcggca ctgactggtg gtcactttag ttgggagttc      780
gattggagcg gtcatccagg tgcgaagacc ccgtggacgg gtcagttgat catcgtgatc      840
aatccaggta aagcagaagg tgaacgcttc gcccagcgca gtcgtgagtt agtggaacac      900
atgcaggccg ttggtctgac ccgcatgccg ggtgaacgtc gctaccgtga gcgcgaggtg      960
gcggaagaag aaggtgttgc ggtgaccgaa caggagttgc aaggcctgaa agaactgctt     1020
ggt                                                                   1023
```

<210> 106
<211> 341
<212> PRT
<213> Pseudomonas putida

<400> 106

```
Met Ser Ala Pro Ser Thr Ser Thr Val Val Arg Val Pro Phe Thr Glu
1               5                   10                  15
Leu Gln Ser Leu Leu Gln Ala Ile Phe Gln Arg His Gly Cys Ser Glu
            20                  25                  30
Ala Val Ala Arg Val Leu Ala His Asn Cys Ala Ser Ala Gln Arg Asp
        35                  40                  45
Gly Ala His Ser His Gly Val Phe Arg Met Pro Gly Tyr Val Ser Thr
    50                  55                  60
Leu Ala Ser Gly Trp Val Asp Gly Gln Ala Thr Pro Gln Val Ser Asp
65                  70                  75                  80
Val Ala Ala Gly Tyr Val Arg Val Asp Ala Ala Gly Gly Phe Ala Gln
                85                  90                  95
Pro Ala Leu Ala Ala Ala Arg Glu Leu Leu Val Ala Lys Ala Arg Ser
            100                 105                 110
Ala Gly Ile Ala Val Leu Ala Ile His Asn Ser His His Phe Ala Ala
        115                 120                 125
Leu Trp Pro Asp Val Glu Pro Phe Ala Glu Glu Gly Leu Val Ala Leu
```

```
    130                 135                 140
Ser Val Val Asn Ser Met Thr Cys Val Val Pro His Gly Ala Arg Lys
145                 150                 155                 160
Pro Leu Phe Gly Thr Asn Pro Ile Ala Phe Ala Ala Pro Cys Ala Glu
                165                 170                 175
His Asp Pro Ile Val Phe Asp Met Ala Thr Ser Ala Met Ala His Gly
            180                 185                 190
Asp Val Gln Ile Ala Ala Arg Ala Gly Gln Gln Leu Pro Glu Gly Met
        195                 200                 205
Gly Val Asp Ala Asp Gly Gln Pro Thr Thr Asp Pro Lys Ala Ile Leu
    210                 215                 220
Glu Gly Gly Ala Leu Leu Pro Phe Gly Gly His Lys Gly Ser Ala Leu
225                 230                 235                 240
Ser Met Met Val Glu Leu Leu Ala Ala Ala Leu Thr Gly Gly His Phe
                245                 250                 255
Ser Trp Glu Phe Asp Trp Ser Gly His Pro Gly Ala Lys Thr Pro Trp
            260                 265                 270
Thr Gly Gln Leu Ile Ile Val Ile Asn Pro Gly Lys Ala Glu Gly Glu
        275                 280                 285
Arg Phe Ala Gln Arg Ser Arg Glu Leu Val Glu His Met Gln Ala Val
    290                 295                 300
Gly Leu Thr Arg Met Pro Gly Glu Arg Arg Tyr Arg Glu Arg Glu Val
305                 310                 315                 320
Ala Glu Glu Glu Gly Val Ala Val Thr Glu Gln Glu Leu Gln Gly Leu
                325                 330                 335
Lys Glu Leu Leu Gly
            340
```

<210> 107
<211> 1206
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized Beta-alanopine dehydrogenase from Cellana grata [BADH]

<400> 107

```
atgcaggaaa agctgattgt tgttgtttgt ggaggtggta acgccgccca cgtcatgtcg       60
ggtctttctg catcacgtga aaatgtggaa gtccgtgtct tggacgtttt tagcgacgag      120
gccgaacgtt ggacgaaaac tcttggtgat gattctattg tcctgacagt aaatcacccc      180
gatggcagtc acgatgaagt ccgcggtaaa ccaaatttca ttacgaacga cgcgtcaaaa      240
gctgtccccg gcgctaacct catcgtgttt gctgttccag ctttcgcgca tgagtcatat      300
tttgaagcca tcaagcctta tgttaaaccc aatatgatta tagtgggcat gcctgggcag      360
ccaggctttg agtttcaatg tttttccatt ctgaaagaca ttgcccctaa gtgctgtgtg      420
attgttttcg aggggcttcc ttgggcggca cgcattaccg agttcggaag agcgatcacc      480
gtattgtcta cgaaagactt cttaaattgc gttgtgatca aaggggaatc gaaaattgag      540
ggagatcccc ttaaaccgat tcaatacctg ttgggtccac atcctgtcgc gacgaaactg      600
cataatttcc ttgaaccgac gctcagcact aagtcgatca tgcaccctcc aattatgtat      660
ggggcttgga aggattggga tggtaaccct ttgtcagaga agccgctgtt ctatcaggga      720
ctgaccgaag aagccgccga gcttatgagc ggtatgtccg atgaacttct tgcgacagct      780
aaagcgatta gcctgaaaaa gcctgaaatc aatctggatg gagtttcaca catacgtgat      840
tggatgtacc aagcctatgg tcgtgagtgt tcggacactt ctaacttgct ccaaatgtta      900
cgtacgaact cagcttacaa tggcctgttg catcctatga aagaggttaa accgggtaaa      960
tttatgccgg acttcacgtt tcggtacctg acagaggata tcccgtttgg cgttgtcgta     1020
ttgaagggaa tttccgaact ggctggcgtt gatactccta tcacagacaa agtgcttgca     1080
tggggacagc agataattgg caaagagtat ctggtgggca aaagcctttg cggaaaagac     1140
gtcgctacct ctagagctcc acagcggtat gggtataagt ccctggacga ctttgaccca     1200
ttgttg                                                                1206
```

<210> 108
<211> 402
<212> PRT
<213> Cellana grata

<400> 108

```
Met Gln Glu Lys Leu Ile Val Val Val Cys Gly Gly Gly Asn Ala Ala
1               5                  10                  15
His Val Met Ser Gly Leu Ser Ala Ser Arg Glu Asn Val Glu Val Arg
            20                  25                  30
Val Leu Asp Val Phe Ser Asp Glu Ala Glu Arg Trp Thr Lys Thr Leu
        35                  40                  45
Gly Asp Asp Ser Ile Val Leu Thr Val Asn His Pro Asp Gly Ser His
    50                  55                  60
Asp Glu Val Arg Gly Lys Pro Asn Phe Ile Thr Asn Asp Ala Ser Lys
65                  70                  75                  80
Ala Val Pro Gly Ala Asn Leu Ile Val Phe Ala Val Pro Ala Phe Ala
                85                  90                  95
His Glu Ser Tyr Phe Glu Ala Ile Lys Pro Tyr Val Lys Pro Asn Met
            100                 105                 110
Ile Ile Val Gly Met Pro Gly Gln Pro Gly Phe Glu Phe Gln Cys Phe
        115                 120                 125
Ser Ile Leu Lys Asp Ile Ala Pro Lys Cys Cys Val Ile Val Phe Glu
    130                 135                 140
Gly Leu Pro Trp Ala Ala Arg Ile Thr Glu Phe Gly Arg Ala Ile Thr
145                 150                 155                 160
Val Leu Ser Thr Lys Asp Phe Leu Asn Cys Val Val Ile Lys Gly Glu
                165                 170                 175
Ser Lys Ile Glu Gly Asp Pro Leu Lys Pro Ile Gln Tyr Leu Leu Gly
            180                 185                 190
Pro His Pro Val Ala Thr Lys Leu His Asn Phe Leu Glu Pro Thr Leu
        195                 200                 205
Ser Thr Lys Ser Ile Met His Pro Pro Ile Met Tyr Gly Ala Trp Lys
    210                 215                 220
Asp Trp Asp Gly Asn Pro Leu Ser Glu Lys Pro Leu Phe Tyr Gln Gly
225                 230                 235                 240
Leu Thr Glu Glu Ala Ala Glu Leu Met Ser Gly Met Ser Asp Glu Leu
                245                 250                 255
Leu Ala Thr Ala Lys Ala Ile Ser Leu Lys Lys Pro Glu Ile Asn Leu
            260                 265                 270
Asp Gly Val Ser His Ile Arg Asp Trp Met Tyr Gln Ala Tyr Gly Arg
        275                 280                 285
Glu Cys Ser Asp Thr Ser Asn Leu Leu Gln Met Leu Arg Thr Asn Ser
    290                 295                 300
Ala Tyr Asn Gly Leu Leu His Pro Met Lys Glu Val Lys Pro Gly Lys
305                 310                 315                 320
Phe Met Pro Asp Phe Thr Phe Arg Tyr Leu Thr Glu Asp Ile Pro Phe
                325                 330                 335
Gly Val Val Val Leu Lys Gly Ile Ser Glu Leu Ala Gly Val Asp Thr
            340                 345                 350
Pro Ile Thr Asp Lys Val Leu Ala Trp Gly Gln Gln Ile Ile Gly Lys
        355                 360                 365
Glu Tyr Leu Val Gly Lys Ser Leu Cys Gly Lys Asp Val Ala Thr Ser
    370                 375                 380
Arg Ala Pro Gln Arg Tyr Gly Tyr Lys Ser Leu Asp Asp Phe Asp Pro
385                 390                 395                 400
Leu Leu
```

<210> 109
<211> 1011
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized Tauropine dehydrogenase from Suberites domuncula [TauDH]

<400> 109

```
atgtctaaga aactgacctt tctgtactta tcggagccag acgtaattaa aacgggcctg       60
acgttgacgg agacgattga gctctgcact gaaagcttga aacagcatgg ccttaaagaa      120
gtagaaaacc ctcctaaacc gggtgtacac cctaaagaag acagtttcat taacgcgatg      180
ccgggctggt tgaaacagaa aggagtttgt ggcattaagt gggtatccgg ctttcctgag      240
```

```
aatgtaaagc agcgcctgcc atctatcgtt ggagtaataa tcttgaactc aactgaaacg      300
ggattcccta cggctgttat ggatggcacg tacattacag ctattcgcac cgctgcagtc      360
agtggtgtgt ccgcaaagta ccttgctcgt aaagattctg aagtgttagc cgtaattggt      420
accggtgtac agggtaagta taatacgtta tgcctgacga cagtgttacc ctcaattaag      480
aaagtaaaaa tctttgacac ctgggcaccc tcgctgcaaa cttttcaaga tcagatcaga      540
ccactgctgc ctaacgtcga atttgaaacg gcgtcgtcca tggaggaggc tatccgtgat      600
tcagacgtca ttgtaggagc cactgctaag ttaacagaaa cggtatactc cgatgagtgg      660
gttaaaccgg gtgctcttgt tcttcctatc caggtgggag gttgggatcc ggatgtgctg      720
agcaagtttg ataaagtcgt agcagacgat tgggcgcagt taaaggcaca gcaagacttc      780
tcacggtata cgtcgaattt tgatacgccg tatgcagaac tcggagaaat cgttatgggt      840
aagaagccag gacgcgagaa tgaccaggag aagatcatta attttaacaa aggtctggcg      900
gtgcatgaca tgatctgcgg tggccgggtt cttgaaaaag cgaagaaaca aggtctgggt      960
gttgaactgg agttaatgga tcttggctcc cctattccta tgccgcctgt t               1011


<210>  110
<211>  337
<212>  PRT
<213>  Suberites domuncula

<400>  110
Met Ser Lys Lys Leu Thr Phe Leu Tyr Leu Ser Glu Pro Asp Val Ile
1               5                  10                  15
Lys Thr Gly Leu Thr Leu Thr Glu Thr Ile Glu Leu Cys Thr Glu Ser
            20                  25                  30
Leu Lys Gln His Gly Leu Lys Glu Val Glu Asn Pro Pro Lys Pro Gly
        35                  40                  45
Val His Pro Lys Glu Asp Ser Phe Ile Asn Ala Met Pro Gly Trp Leu
    50                  55                  60
Lys Gln Lys Gly Val Cys Gly Ile Lys Trp Val Ser Gly Phe Pro Glu
65                  70                  75                  80
Asn Val Lys Gln Arg Leu Pro Ser Ile Val Gly Val Ile Ile Leu Asn
                85                  90                  95
Ser Thr Glu Thr Gly Phe Pro Thr Ala Val Met Asp Gly Thr Tyr Ile
            100                 105                 110
Thr Ala Ile Arg Thr Ala Ala Val Ser Gly Val Ser Ala Lys Tyr Leu
        115                 120                 125
Ala Arg Lys Asp Ser Glu Val Leu Ala Val Ile Gly Thr Gly Val Gln
    130                 135                 140
Gly Lys Tyr Asn Thr Leu Cys Leu Thr Thr Val Leu Pro Ser Ile Lys
145                 150                 155                 160
Lys Val Lys Ile Phe Asp Thr Trp Ala Pro Ser Leu Gln Thr Phe Gln
                165                 170                 175
Asp Gln Ile Arg Pro Leu Leu Pro Asn Val Glu Phe Glu Thr Ala Ser
            180                 185                 190
Ser Met Glu Glu Ala Ile Arg Asp Ser Asp Val Ile Val Gly Ala Thr
        195                 200                 205
Ala Lys Leu Thr Glu Thr Val Tyr Ser Asp Glu Trp Val Lys Pro Gly
    210                 215                 220
Ala Leu Val Leu Pro Ile Gln Val Gly Gly Trp Asp Pro Asp Val Leu
225                 230                 235                 240
Ser Lys Phe Asp Lys Val Val Ala Asp Asp Trp Ala Gln Leu Lys Ala
                245                 250                 255
Gln Gln Asp Phe Ser Arg Tyr Thr Ser Asn Phe Asp Thr Pro Tyr Ala
            260                 265                 270
Glu Leu Gly Glu Ile Val Met Gly Lys Lys Pro Gly Arg Glu Asn Asp
        275                 280                 285
Gln Glu Lys Ile Ile Asn Phe Asn Lys Gly Leu Ala Val His Asp Met
    290                 295                 300
Ile Cys Gly Gly Arg Val Leu Glu Lys Ala Lys Lys Gln Gly Leu Gly
305                 310                 315                 320
Val Glu Leu Glu Leu Met Asp Leu Gly Ser Pro Ile Pro Met Pro Pro
                325                 330                 335
Val

<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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag   1077

<210> 112
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 112
Met Ile Glu Ser Lys 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
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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ctttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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
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 Thr 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagatcggc tgttgag    1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Asn
145 150 155 160
Phe Ala 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacc gggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg caggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctaggga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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
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
355

<210> 121
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 121
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacatt ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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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 Ser 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 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
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
        355
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<210> 123
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 123

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacaaa tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Asn Ala Met Asp
145   150   155   160
Phe Ala 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
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
        355

<210> 125
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 125
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc ggggctcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Ala Leu Ala Glu 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
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
355

<210> 127
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 127
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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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tgggcttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Gly
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
355

<210> 129
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 129
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
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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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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
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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

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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 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 Asp 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
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
        355
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<210> 131
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 131

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
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cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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
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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu 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
        355

<210> 133
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 133

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatacgg 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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 134
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 134
Met Ile Glu Ser Lys 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
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 Thr 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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                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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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
        355
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<210> 137
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 137

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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
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cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcataggta tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 138
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 138

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1               5                   10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Ser 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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Gly 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn
        275                 280                 285
Leu Asn Thr Val His Val 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
        355


<210> 139
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 139
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcattg cgggacctat ttcgcttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacaat ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Met Ala Met Asp
145   150   155   160
Phe Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Asn

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        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
        355


<210> 143
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 143
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac gaaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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
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    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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
        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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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaataca aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Lys Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattt atggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Tyr 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
355

<210> 149

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

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

<400> 149
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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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aagagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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

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                245                 250                 255
Glu Trp His Lys Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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> 151
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 151
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
tctagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
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            100                 105                 110
Gly Gly Ala 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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
        355
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<210> 153
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 153
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 caagatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Lys Met Asp
145 150 155 160
Phe Ala 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
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

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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
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cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
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 Leu 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
355

<210> 159
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 159
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
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tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
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cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 160
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 160
Met Ile Glu Ser Lys 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
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 Thr Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
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
355

<210> 161
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 161
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
ggtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Gly Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
        355

<210> 163
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 163
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120

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 aggactggtt acggtaaatg cgataacagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Leu 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
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 ggaggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Glu Val Leu Pro Gln Tyr Val Ala Val Glu Asn Val Leu His Thr

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            180                 185                 190
Ser Leu Thr Asn Ile Glu 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
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcatggg 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ser 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 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 Gly Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
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
        355
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<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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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
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
        355

<210> 171
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 171
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta agggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Lys 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
355

<210> 173
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 173
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacaga cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcatgggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Asp Ala Met Asp

```
145                 150                 155                 160
Phe Ala 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 Trp 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
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
        355
```

<210> 175
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 175
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagggta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 176
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 176
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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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
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
        355
```

<210> 177
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 177
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttgg 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Trp Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
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
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
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca tcagacgggc 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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
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 Arg 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 ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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
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
        355
```

<210> 183
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 183
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggcggcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 184
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 184
Met Ile Glu Ser Lys 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
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 Arg Leu Ala Glu 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
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
        355

<210> 185
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 185
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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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggaccttc gaaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 186
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 186
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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
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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ser 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
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
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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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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
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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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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
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 Val Asp Phe 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
355

<210> 189
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 189
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctaagga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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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 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 Lys Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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
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
        355
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<210> 191
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 191

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacacg tgccatggac 480
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<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
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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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 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
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
355

<210> 195
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 195
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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccgc tgatataggt 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggcggcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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
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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 Ala 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Leu Ala Glu 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
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
355

<210> 197
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 197
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gttgtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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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 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
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 Val 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
        355
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<210> 199
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 199

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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaga taagaagtgc tgttgag    1077
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<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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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
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
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

atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
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 tccgtgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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
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 Arg 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
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
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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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
        355
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<210> 205
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 205
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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 ttctgaccga tgatataggt 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
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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
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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
Leu Thr Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
        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
        355
```

<210> 207
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 207

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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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Val Ala Arg Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Gly

```
        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 Val 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
        355
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<210> 211
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 211
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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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

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

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

<400> 212
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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 Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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
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```
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Arg Ala Lys Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser
        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 Thr 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
        355
```

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

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

<400> 213
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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 Arg Ala Met Asn
145 150 155 160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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
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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 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 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Val Ala Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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

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                245                 250                 255
Glu Trp His Lys Glu Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Gly
        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 Val 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
        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
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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
        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 Val 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
        355
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<210> 221
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 221
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacc gtgctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser
        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
        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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Val Ala Arg Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
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

355

<210> 225
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 225
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 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccaatcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Thr 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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 Val 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
        355
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<210> 227
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 227
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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 ttctgaccga tgatataggt 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 cgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat taaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 228
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 228
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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 Asp 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 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 Asn
145 150 155 160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggttaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Val Val Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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 Val 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
        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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Arg Ala Arg Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Gly
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
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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 234
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 234
Met Ile Glu Ser Lys 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 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 Thr 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Thr 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
        355
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<210> 235
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 235
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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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 236
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 236
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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 Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 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 Asp Tyr Tyr Thr 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Thr 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
        355
```

<210> 237
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 237
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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 ttctgaccga tgatataggt 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 tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
```

gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Asn
145   150   155   160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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 Thr 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
        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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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
        355
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<210> 241
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 241

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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 Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Asn
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145                 150                 155                 160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Thr 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
        355
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<210> 243
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 243

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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 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
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 244
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 244

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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Lys Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Gly
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Thr 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
        355
```

<210> 245
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 245
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Gly
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Thr 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
355

<210> 247
<211> 1077
<212> DNA

<213> Artificial Sequence

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

<400> 247
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Arg Ala Arg Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser
        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
        355


<210> 249
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 249
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Met Asn
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
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
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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Arg Ala Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
355

<210> 255
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 255
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Arg Ala Arg Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Thr 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
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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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
        355
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<210> 259
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 259
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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 ttctgaccga tgatataggt 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 cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Met Asn
145   150   155   160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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 Val 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
        355

<210> 261
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 261
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Thr 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
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 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Thr 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Thr 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
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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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

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    50                  55                  60
Leu Thr Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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
        355
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<210> 267
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 267
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccaatcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Met Asn
145   150   155   160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Thr 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
        355

<210> 269
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 269

atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Val Ala Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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 Val 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
355

<210> 271
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 271
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Met Asn
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 Val Ala Arg Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
        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 Val 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
        355
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<210> 273
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 273
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 274
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 274
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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 Ser 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
Leu Thr Asp 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Asn
145                 150                 155                 160
Phe Ala 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 Arg Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Gly
        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
        355


<210> 275
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 275
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gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 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 Thr 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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 Thr 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
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 ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ile Ser

        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
        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 ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Arg Ala Arg Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Gly
        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
        355
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<210> 281
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 281
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Val Ala Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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 Thr 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
355

<210> 283
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 283
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
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 Val 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
355

<210> 285

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

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

<400> 285
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagagtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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
cctcaatacg tggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctat tagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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

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                245                 250                 255
Glu Trp His Lys Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Ile Ser
        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
        355


<210> 287
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 287
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Ala Thr
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            100                 105                 110
Gly Gly Ala 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 Arg Ala Met Asn
145                 150                 155                 160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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
        355
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<210> 289
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 289
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccga tgatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctcgtga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 Asp 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Val Ala Arg Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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
        355

<210> 291
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 291
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatgaac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacg tggctaaaga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattatctgg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Met Asn
145 150 155 160
Phe Ala 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 Lys Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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

355

<210> 293
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 293
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata 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 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 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 Lys Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
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 Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgcccc gtacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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65                  70                  75                  80
Ile Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Asn Ile Ala
                85                  90                  95
Pro Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Lys Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 297
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 297

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Lys Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Lys Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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
        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
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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacacggatt 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 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu 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
Glu Ile Arg Ser Ala Val Glu
355

<210> 301
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 301
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 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
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ala Val Glu Asn Val Leu His Thr

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            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
<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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt 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
Met Ile Glu Ser Lys 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
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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 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 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 Lys Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr 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 Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 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 Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
        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
        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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
ggcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Arg Lys Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Gly Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt 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 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 Lys Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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
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
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 cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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

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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Lys Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe 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
        355
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<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 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
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacacggatt 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 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 Lys Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu 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
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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Gln Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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
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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 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Cys
245 250 255
Glu Trp His Lys Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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
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
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 cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt 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 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 Arg Lys Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Lys Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Thr 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
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 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 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
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacacggatt 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
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 Leu 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
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

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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 cgataacagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
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gctgttctta ccttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
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<210> 324
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 324
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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 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 Lys Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Thr Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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

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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 cgataacacg taaaatggac 480
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cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
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tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<210> 326
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 326
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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 Asn 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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Arg Lys Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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> 327
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 327
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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
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cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<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 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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
        355

<210> 329
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 329
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cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240

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gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
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<210> 330
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 330
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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 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 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
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> 331
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<220>
<223> Engineered variant of opine dehydrogenase CENDH

<400> 331
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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
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<213> Artificial Sequence

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

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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 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 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 Cys
245 250 255
Glu Trp His Lys Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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
Glu Ile Arg Ser Ala Val Glu
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<210> 333
<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
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<210> 334
<211> 359
<212> PRT
<213> Artificial Sequence

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

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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

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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 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 Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 Arg Leu Ala Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr 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 Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 335
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 335

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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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 Thr Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 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 Arg Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Thr 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
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 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
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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

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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 Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
        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 Val Asp Phe 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
        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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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 342
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 342
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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
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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Lys Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 343
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 343

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcattc tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt 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 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 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 Lys Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Arg Leu Ala Glu 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr Ser
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 Thr 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
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 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 atatcgcccc gtacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt 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 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
Pro Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 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 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser

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        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
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 347
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 347
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg taaaatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaataca aagctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattcgat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattg cgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttctta ccttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 Arg Lys Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Lys Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe Asp Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Ala Gly Pro Thr Ser
        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 Thr 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
Glu Ile Arg Ser Ala Val Glu
        355
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<210> 349
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 349
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 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 gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 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 Gln Tyr Tyr Thr 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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
355

<210> 351
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 351
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 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
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
cgtagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Arg Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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
355

<210> 353

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

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

<400> 353
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys

```
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacaat ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag tggcctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Ala Thr
```

```
            100                 105                 110
Gly Gly Ala 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 Met Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Asp Leu Ile Ser Gly 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
        355
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<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 ttctgaccgc ggatataggt 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 cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Leu Ala Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355

<210> 359
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 359
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttacc 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggactggtt acggtaaatg cgataacaca tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Thr Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Leu Val Thr Val Asn Ala Ile Thr His Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Val 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

355

<210> 361
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 361
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctag cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Thr Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Leu Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ser Gly
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 Val 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
355

<210> 363
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 363
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttacc 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggactggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
aaaagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Leu Gly Asn Gly Gly
1 5 10 15
His Ala Phe Thr Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr 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 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 Leu 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Lys Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
        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 Val 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
        355
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<210> 365
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 365

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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccgc ggatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagacgtgc tgttgag    1077
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<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 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 Ala 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
        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 Val 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 Arg 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggactggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagacgtgc 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 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 Leu 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
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 Val 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

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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
Gly Ile Arg Arg Ala Val Glu
        355
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<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 ggattaggaa acgggggtca cgcatttacc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccgc ggatataggt 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 aggactggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctag cggccttaac acggtgcaca tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 370
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 370

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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 Thr Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ala 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Leu 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 Arg Ala Val Glu Asn Val Leu His Thr
```

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Ser Gly
        275                 280                 285
Leu Asn Thr Val His Ile Phe 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 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
        355


<210> 371
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 371
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgaccgc ggatataggt 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 cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
gcgagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattt atggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag tggcctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagacgtgc 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 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 Ala 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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ala Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Tyr Gly Pro Thr 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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Asp Leu Ile Ser Gly 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 Arg 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcattc tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
```

gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Leu Gly Pro Thr 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 Val 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
        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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggactggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cggccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag tggcctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 376
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 376
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 Leu 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Gly
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Asp Leu Ile Ser Gly 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
        355
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<210> 377
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 377

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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 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 gagcgttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt 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

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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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Val 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
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
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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc gcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ctacatttcc 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 380
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 380
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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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Val 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
        355
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<210> 381
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 381
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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gcttgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttctt   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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Leu
        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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gctattcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 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 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Tyr Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa ctatcgccag 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Thr Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355

<210> 389
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 389
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acaatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacagg cgccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
355

<210> 391
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 391
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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga atttggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Phe 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
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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Arg 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 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355
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<210> 395
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 395
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atgatcgagt caaaaacata tgccgttttg 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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 acatcgatgc tcagagaatc 120
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 gtcggaactt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag 1077

<210> 398
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 398
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 Glu Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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

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            340                 345                 350
Gly Ile Arg Ser Ala Val Glu
        355
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<210> 399
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 399
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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gcggttcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag   1077

<210> 400
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 400
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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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu 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 Gln Tyr Tyr Thr 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 Ser Ser Tyr Gly Gly Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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 acatcgatgc tcagagaatc 120
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 aacagatatg ttcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile 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 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
Cys Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355
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<210> 403
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 403

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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgttga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Val
                245   250   255
Glu Trp His Lys Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcacg cattcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Asn
275 280 285
Leu Asn Thr Val His Ala 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
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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcacg ttttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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

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                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Asn
        275                 280                 285
Leu Asn Thr Val His Val 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
        355
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<210> 409
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 409

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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcacg ttttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 410
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 410

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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
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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Asn
        275                 280                 285
Leu Asn Thr Val His Val 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
        355
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<210> 411
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 411

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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcatta tgggacctac caaccttaac acggtgcacg cattcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Asn
275 280 285
Leu Asn Thr Val His Ala 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
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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacagtga 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Leu Ala Val Lys Asp Ser 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
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
tttgcaacac tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Thr Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600

ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttgttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Val 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
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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttattg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Ile 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
        355
```

<210> 423
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 423

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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttacag acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
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<210> 424
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 424

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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 Ala Thr
```

```
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Thr 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
        355
```

<210> 425
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 425
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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttgttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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 Val 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
        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 acatcgatgc tcagagaatc 120
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 cgataacaat ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Met Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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

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 acatcgatgc tcagagaatc 120
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 acggtaaatt atataacagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Tyr 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355
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<210> 431
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 431
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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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcattggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 432
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 432
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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
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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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 Ser Leu Ala Glu Lys Val Asp Ala Glu
225 230 235 240
Arg Ile Ala Ile Ala Leu Ala Phe Asp Leu Asn Val Pro Ser Val Cys
245 250 255
Glu Trp His Lys Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
355

<210> 433
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 433
atgatcgagc ttaaaacata 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 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Leu Lys 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 acatcgatgc tcagagaatc 120

aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataaat ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atattgccag 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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Asn 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 acatcgatgc tcagagaatc 120
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 acggtaaatc aaataacagg cgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca taagaagtgc tgttgag    1077
```

<210> 438
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 438

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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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Gln 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 Arg Ala Val Glu Asn Val Leu His Thr
```

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaagc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
```

```
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        355
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<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 ccagacagta ctggcttggg acatcgatgc tcagagaatc 120
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
cctcaatacc gtgctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccaa 660
tattataccg aggggattac gccatcagtc gggagtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
agcagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac caaccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
```

gctgttcttg acttgatcag ttcgctgata gacacggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcgggca 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 Thr Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Arg Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu 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 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 Ser Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr 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
        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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttccttga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Leu 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Tyr Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 447
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 447

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 ggattaggac caggggtca 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Pro Gly Gly
1 5 10 15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ser 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu

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            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttgtgc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Tyr Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 acatcgatgc tcagagaatc 120
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 acggtaaatc agataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgtttgcc 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Gln Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Cys Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 ccagaccgta ctggcttggg acatcgatca tcagagaatc 120
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 acggtaaatc agataacccg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 Thr Val Leu Ala
20 25 30
Trp Asp Ile Asp His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ile Thr 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 Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 acatcgatgc tcagagaatc 120
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 cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttatctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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

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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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Tyr Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 463
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 463

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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt 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 cggtctgcga atggcataag 780
attagttacg gctattcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ser Met Leu Phe Thr Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Asn 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 Cys
                245   250   255
Glu Trp His Lys Ile Ser Tyr Gly Tyr Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 acatcgatgc tcagagaatc 120
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 cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaata tgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Met Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Leu Lys 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

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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 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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 471
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 471

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 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 Cys
                245   250   255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtc tgaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttatgacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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
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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
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 Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Leu 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 Phe Met Thr 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 Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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

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atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatca tcagagaatc 120
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
atcctgcgta acaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttatgacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
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cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgtttgcc 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 His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Asn 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 Phe Met Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Cys Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgta acaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgatgacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg 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 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 Asn 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 Met Thr 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 Cys
                245   250   255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser

```
        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 Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 483
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 483

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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcacg cgttcgagga tgtaagcacc 900
ggactggtac cgttatccga atttggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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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 Ser Met Leu Phe Thr Cys Arg Ser
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130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Ala Phe Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Phe Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 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 atggcataag 780
attagttacg gctattcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser 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 His Lys Ile Ser Tyr Gly Tyr Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Val Val Pro Ala Ile His His Ala Ser Ile Ala Ala Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcggctcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gly Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtc tgaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgatgacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Leu 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 Met Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgaggc agtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys
                245   250   255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Val His Phe Phe Glu Ala 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
<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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatc agataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Gln Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttatgacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Phe Met Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg tgcgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Phe Ile Thr 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 Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Cys Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 acatcgatca tcagagaatc 120
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 acggtaaatt ttatgacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tggcctgata 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 His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 Phe Met Thr 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 Arg Leu Ala Glu 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 His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Gly Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
attgtagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacaat 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga atttggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Met Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Phe Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys

                325   330   335
Glu Gly Arg Thr 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 acatcgatca tcagagaatc 120
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
atcctgcgtc tgaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatc agatgacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Leu 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 Gln Met Thr 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

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            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaata tgataacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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
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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 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 Met Ile Thr 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 Arg Leu Ala Glu 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 His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 509
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 509
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga agatcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960

gctgttcttc tgttgatcag ttcgctgata 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 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 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 Cys
                245   250   255
Glu Asp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacaat 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr Met Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcggctcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gly Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 ccagaccgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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1               5                   10                  15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Thr Val Leu Ala
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggttgac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720

cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Leu Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgatgacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttatgc 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 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 Met Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu

260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Met Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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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 acggtaaatc agataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg tgcgtgaatg 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
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His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Thr Val Leu Ala
20 25 30
Trp Asp Ile Asp His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Gln Ile Thr 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Cys Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 523
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 523
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcacg tgttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ser Met Leu Phe Thr Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Val His Val 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacaat ggccatggac 480

tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Phe Ile Thr Met Ala Met Asp
145 150 155 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
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ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttgtgc tgttgatcag ttcgctgata 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 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 Arg Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Leu Ala Met Asp
145   150   155   160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165   170   175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 529
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 529
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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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact 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 cggtctgcga atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
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gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
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<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 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 Arg 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 Ser 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 His Lys Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Phe Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 531
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 531

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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 acggtaaata tgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcacccgc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg tgcgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
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<210> 532
<211> 359

<212> PRT
<213> Artificial Sequence

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

<400> 532
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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
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 Ala Thr
            100   105   110
Gly Gly Ala 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 Met Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Arg Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Cys Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly 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> 533
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 533
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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 acggtaaata tgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Met Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 535
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 535
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Phe Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
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cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atggcataag 780
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ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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
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 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 Leu Ala Met Asp
145                 150                 155                 160
Phe Ala Cys Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
                165                 170                 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 539
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 539

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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
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gctgttgtgc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
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<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 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
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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

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aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggttc gtgacgctga 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 cgataacacg tgccatggac 480
tttgcaaccc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc 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 atggcataag 780
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cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
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<210> 542
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 542
Met Ile Glu Arg Lys 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 Arg 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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg Ala Met Asp
145 150 155 160
Phe Ala Thr Leu Pro Ala Ala Lys Ala Gly Trp Ala Leu Glu Gln Ile
165 170 175
Gly Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaata tgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg 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
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 Met Ile Thr Arg 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaata tgatgacacg 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 cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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> 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 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 Met Met Thr 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 Val
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840

cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttaccc tgttgatcag ttcgctgata 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 His Lys 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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Thr Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcacg tgttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser

275 280 285
Leu Asn Thr Val His Val 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg tgcgtgaatg tgcctacccc acttatcgat 960
gctgttctgc tgttgatcag ttcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Phe Ile Thr 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Cys Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 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 acatcgatca tcagagaatc 120
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
atcctgcgtc tgaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg tgcgtgaatg tgcctacccc acttatcgat 960
gctgttatgc 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 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 His Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Leu 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 Phe Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Cys Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Met Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Tyr Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 ccatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Thr Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys

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                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttattc tgttgatcag ttcgctgata 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 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 Ala Thr
```

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            100                 105                 110
Gly Gly Ala 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 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Ile Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 561
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 561
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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttatgacacg 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 gggcgtcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtcgtgga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 Ala Thr
            100   105   110
Gly Gly Ala 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 Phe Met Thr 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 Arg Leu Ala Glu 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 His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360

atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatc agataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Val Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgta acaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatc agataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatatg ctcggttctt 540
cctcaatacc 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 atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala Leu Glu Phe Arg Lys Ile Leu Arg Asn 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 Gln Ile Thr 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
Cys Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatc agataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg 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
Met Ile Glu Ser Lys 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 Ala Thr
100 105 110
Gly Gly Ala 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 Gln Ile Thr 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 ccatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga atttggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Thr Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys
                245   250   255
Glu Trp His Lys Ile Ser Tyr Gly Leu Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Phe Gly Arg Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys

```
                325                 330                 335
Glu Gly Arg Thr 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

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atggcataag 780
attagttacg gccagtcacc ggccacaggt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 574
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 574

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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 Ala Thr
            100                 105                 110
Gly Gly Ala 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 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 Cys
                245                 250                 255
Glu Trp His Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Gly Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 atggcataag 780
attagttacg gcggctcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcacg cgttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ile Ser Tyr Gly Gly Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Ala 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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

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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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
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gctgttcttc tgttgatcag ttcgctgata 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 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 Arg Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Tyr Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro

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    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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 581
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 581

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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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 Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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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 aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Ser Met Leu Phe Thr Cys Arg Ser
    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 585
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 585
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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Arg Ile Ala
                85   90   95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100   105   110
Gly Gly Ala 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 Tyr Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu

260 265 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Arg 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

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        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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 591
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 591
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 592
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 592
Met Ile Glu Ser Lys 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 Ser Met Leu Phe Thr Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Arg 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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

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                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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 599
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 599
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 Ser Met Leu Phe Thr Cys Arg Ser
    130   135   140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        275   280   285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
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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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Ser Met Leu Phe Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp 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
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<210> 603
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 603
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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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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 Arg Ile Ala
                85                  90                  95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg 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 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
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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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile 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 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Arg 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 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260   265   270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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

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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 atatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Tyr Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
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 cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 Arg 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
        275                 280                 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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 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 gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 614
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 614
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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
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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
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 Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tccttttctg 840
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cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Ala Val Gln Gly Asn Pro Phe Leu Arg Gly Ile Met Gly Pro Thr Ser
275 280 285
Leu Asn Thr Val His Phe Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<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 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 acggtaaatt atataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Asn Tyr Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 619
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 619
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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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgctctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Val Gln Gly Asn Pro Ala Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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
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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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg gcaacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaag tatgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Arg Ile Ala
85 90 95
Ser Tyr Ile Ser Glu Gly Gln Leu Ile Ile Leu Asn Pro Gly Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<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 acatcgatgc tcagagaatc 120
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 cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttctggga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Ala Thr
100 105 110
Gly Gly Ala 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Trp 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 625

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

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

<400> 625
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 attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Arg 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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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

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                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Leu Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355


<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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gcctgacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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
Met Ile Glu Ser Lys 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
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            100                 105                 110
Gly Gly Ala Leu Glu Phe Arg 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Leu 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 Ala Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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
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gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Val 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340   345   350
Glu Ile Arg Ser Ala Val Glu
        355

<210> 631
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 631
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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Asn Ala Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu

355

<210> 633
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 633
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Val 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 Arg 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 635
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 635
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 ccatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc 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> 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Thr 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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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> 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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg 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
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Arg 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290   295   300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 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 ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Asn Ala Ile Thr 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 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 Ser Leu Ile Asp Val Asp Phe Arg Lys

```
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 641
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 641

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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 attgcagcac gtatcgccag 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
cctcaatgcc 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 gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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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 Arg 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
```

```
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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 aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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

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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 Cys 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 Arg 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Phe 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> 645
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 645

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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
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 540
cctcaatgcc 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 gcctgacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
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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 Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Asn Ala Ile Thr 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
His Ser Val Leu Pro Gln Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu 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 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 Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 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> 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Asn Ala Ile Thr 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 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> 649
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 649

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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
acatgccgct ccgagagacc aggacaggtt acggtaaatt 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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

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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 Asn 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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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 gtggcggtta 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 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 gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50                  55                  60
Leu Thr Ser Asp Ile Gly Val 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
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340                 345                 350
Glu Ile Arg Ser Ala Val Glu
        355
```

<210> 653
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 653

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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 tgcgcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Cys 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 Arg 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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 655
<211> 1077
<212> DNA

<213> Artificial Sequence

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

<400> 655
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 acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe 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> 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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt ttggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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
Met Ile Glu Ser Lys 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 Arg 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

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        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 Tyr Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe 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 Ala Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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
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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
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Asn Tyr Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu 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 Ala Val Asn Val Pro Thr Pro Leu Ile Asp
305   310   315   320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340   345   350
Glu Ile Arg Ser Ala Val Glu
        355

<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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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 aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Cys 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 Arg 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc 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> 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Val 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Leu Ser 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> 665
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 665
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 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
gctgttcttc tgttgatcag tgaactgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 666
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 666
Met Ile Glu Ser Lys 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

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                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 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
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<210> 667
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 667
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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 gtggcggtta 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 acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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> 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Val 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Phe 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> 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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta aagacgctga tgtgatactg 240

attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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 atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Val 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 Arg 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
Glu Trp Val Lys Ile Ser Tyr Gly Leu Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu

195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 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 gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile 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 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
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 675
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 675
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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 gtggcggtta 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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> 676
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 676
Met Ile Glu Ser Lys 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 Val 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe 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> 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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta 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 acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Cys 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg 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
Met Ile Glu Ser Lys 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 Asn Ala Ile Thr Arg 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 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 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 gcctgacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 682
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 682
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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
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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
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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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

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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
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
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cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa 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 Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
1   5   10   15
His Ala Phe Ala Ala Tyr Leu Ala Leu Lys Gly Gln Arg Val Leu Ala
            20   25   30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Cys 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 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Leu Ser 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 Phe 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<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 cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta 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 acggtaaatt 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 gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Cys 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

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    130                 135                 140
Glu Arg Pro Gly Gln Val Thr Val Asn 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 Leu Ser 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 Phe 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> 689
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 689
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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
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 691
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 691
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatt atataacacg 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 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 ttcgctgata 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 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 Val 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 Arg 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 Tyr Ile Thr 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 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc 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> 694
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 694
Met Ile Glu Ser Lys 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 Asn Ala Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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> 695
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 695
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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 attgcagcac gtatcgccag 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 atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
            20                  25                  30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Arg 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
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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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 tgcgcggtta 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Cys 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 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca ttcggttctt 540
cctcaatgcc 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 gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 Asn Ala Ile Thr 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
His Ser Val Leu Pro Gln Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Glu Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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 aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
50 55 60
Leu Thr Ser Asp Ile Gly Val 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 Arg 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu

210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
290 295 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt tgcgcggtta 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatgcc 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 ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 704
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 704
Met Ile Glu Ser Lys 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 Cys 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 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
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 acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcac gtatcgccag 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 atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35   40   45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    50   55   60
Leu Thr Ser Asp Ile Gly Val 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 Arg 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
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe 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> 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 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 acggtaaatg cgataacact ggccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 Lys Gly Gln Arg Val Leu Ala
20 25 30
Trp Asp Ile Asp Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
35 40 45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305 310 315 320
Ala Val Leu Leu Leu Ile Ser Ala Leu Ile Asp Val Asp Phe Arg Lys

                325   330   335
Glu Gly Arg Thr 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 ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gcctgacccc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga 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 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 Val 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Leu 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 Phe 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> 711
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 711
atgatcgagt caaaaacata cgccgttttg ggattaggaa acgggggtca cgcatttgcc 60
gcctatttag cattgaaggg ccagcgtgta ctggcttggg acatcgatgc tcagagaatc 120
aaagagattc aggaccgtgg agccatcata gcggaaggac caggacttgc tgggactgct 180
cacccggatc ttctgacctc agatataggt gtggcggtta 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 acggtaaatt atataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg accgtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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
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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 Val 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 Tyr Ile Thr 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180                 185                 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195                 200                 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210                 215                 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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 Phe Glu Asp Val Ser Thr Gly Leu Val Pro
    290                 295                 300
Leu Ser Glu Leu Gly Arg Thr Val Asn Val Pro Thr Pro Leu Ile Asp
305                 310                 315                 320
Ala Val Leu Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 713
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 713
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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 gtggcggtta aagacgctga tgtgatactg 240
attgtagtgc cggccatcca ccacgcttcc attgcagcaa ccatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagataca 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcagcgagga 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> 714
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 714
Met Ile Glu Ser Lys 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 Val 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 Thr 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 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
His Ser Val Leu Pro Gln Tyr Gln Ala Val Glu Asn Val Leu His Thr
            180   185   190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
        195   200   205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
    210   215   220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Ser 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> 715
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 715
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 attgcagcac gtatcgccag 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
cctcaatgcc 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 gcctgtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gtggtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag tgcgctgata 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 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 Arg 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 Cys Gln Ala Val Glu Asn Val Leu His Thr
180 185 190
Ser Leu Thr Asn Ile Glu Ala Val Leu His Pro Leu Pro Thr Leu Leu
195 200 205
Asn Ala Ala Arg Cys Glu Ser Gly Thr Pro Phe His Tyr Tyr Thr Glu
210 215 220
Gly Ile Thr Pro Ser Val Gly Ala Leu Ala Glu 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 Leu Ser 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 Phe 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 Ala Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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
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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
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtat tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
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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 Ala Gln Arg Ile Lys Glu Ile Gln Asp Arg Gly Ala
        35                  40                  45
Ile Ile Ala Glu Gly Pro Gly Leu Ala Gly Thr Ala His Pro Asp Leu
    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 Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 721
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 721
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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaatggg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttggtcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Trp Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Val Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtgc acctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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 Asn Ala Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaatggg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
260 265 270
Trp Val Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 727
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 727
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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcgtta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag 1077

<210> 728
<211> 359
<212> PRT
<213> Artificial Sequence

<220>

<223> Engineered variant of opine dehydrogenase CENDH

<400> 728
Met Ile Glu Ser Lys 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 Asn Ala Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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
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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctttgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 731
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 731
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 acggtaaatg cgataacacg 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 cggtctgcga atggtggaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag   1077

<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 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 Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Trp Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg tgccatggac 480
tttgcatgtc tcccagcggc aaaagctgga tgggccctgg aacagatagg gtcggttctt 540
cctcaatacc aggctgtcga aaacgtgttg catacttcgc tgactaatat cgaagctgta 600
ttgcaccctc tgccaacact gttaaacgct gctcgttgtg agtctggtac cccattccat 660
tattataccg aggggattac gccatcagtc ggggcgcttg cggagaaagt ggacgctgaa 720
cgcatagcaa tcgcaaaggc tttcgattta aacgttccgt cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcga tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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

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                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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser Pro Ala Thr Ile Tyr Glu
            260                 265                 270
Ala Met Gln Gly Asn Pro Val Leu Arg Gly Ile Met Gly Pro Thr Ser
        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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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
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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
acatgccgct ccgagagacc aggacaggtt acggtaaatt ttataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<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 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 Asn Phe Ile Thr 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala
            340   345   350
Glu Ile Arg Ser Ala Val Glu
        355

<210> 737
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 737
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 acggtagttg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Val Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr Leu Glu Lys Leu Gly Leu Ser Gly Leu Thr Ala Ala

340 345 350
Glu Ile Arg Ser Ala Val Glu
355

<210> 739
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 739
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 acgatcggtg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtatatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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
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 cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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
Met Ile Glu Ser Lys 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

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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 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 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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> 743
<211> 1077
<212> DNA
<213> Artificial Sequence

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

<400> 743

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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 cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata gacgtggatt tcagaaagga aggtcgtacc 1020
ttggaaaaat taggtctgag cggacttacc gccgcggaaa taagaagtgc tgttgag    1077
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<210> 744
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 744
Met Ile Glu Ser Lys 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 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 Cys
                245   250   255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325   330   335
Glu Gly Arg Thr 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 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
attccagtgc cggccatcca ccacgcttcc attgcagcaa aaatcgccag ttacatttcc 300
gagggtcagt tgattatcct taaccctggg cgtacgggtg gagcgctgga attccggaaa 360
atcctgcgtg aaaatggtgc gccggaggta acgatcgggg aaacctcaaa catgctcttt 420
acatgccgct ccgagagacc aggacaggtt acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgagga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Thr Cys Arg Ser
130 135 140
Glu Arg Pro Gly Gln Val Thr Val Asn Ala Ile Thr 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 Cys
245 250 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
325 330 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
cgcggcatta tgggacctac cagccttaac acggtgcact tcttcgtgga tgtaagcacc 900
ggactggtac cgttatccga actgggtcgg gcagtgaatg tgcctacccc acttatcgat 960
gctgttcttc tgttgatcag ttcgctgata 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 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 Asn Ala Ile Thr Arg 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Val 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg Thr 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 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 acggtaaatg cgataacacg 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 cggtctgcga atgggttaag 780
attagttacg gccagtcacc ggccacaatt tatgaagcgg tgcagggtaa tcctgtgctg 840
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<210> 750
<211> 359
<212> PRT
<213> Artificial Sequence

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

<400> 750
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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
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 Asn Ala Ile Thr 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 Cys
                245                 250                 255
Glu Trp Val Lys Ile Ser Tyr Gly Gln Ser 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 Phe Asn 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 Leu Leu Ile Ser Ser Leu Ile Asp Val Asp Phe Arg Lys
                325                 330                 335
Glu Gly Arg 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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