

SEQUENCE LISTING

<110> CODEXIS, INC.
CHNG, CHINPING
HALLOWS, WILLIAM CASEY
AGARD, NICHOLAS J.
ALVIZO, OSCAR
DELLAS, NIKKI
HUISMAN, GJALT W.
NICOLS, JOHN JOSEPH

<120> ENGINEERED PHENYLALANINE AMMONIA LYASE POLYPEPTIDES

<130> CX7-159USP1

<140> TO BE ASSIGNED

<141> 2017-02-13

<160> 12

<210> 1

<211> 1701

<212> DNA

<213> Artificial Sequence

<220>

<223> *Anabaena variabilis* PAL

<400> 1

```
atgaaaaccc tgagccaggc acagagcaaa accagcagcc agcagtttag ctttaccggc 60
aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgcacgt 120
gttgcccgta atggcaccct ggtagcctg accaataata ccgatattct gcagggtatt 180
caggccagct gtgattatat caataatgca gttgaaagcg gtgaaccgat ttatggtgtt 240
accagcggtt ttggtggtat ggcaaatgtt gcaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaaat agccacatgc gtggtgcaag cggatattcg 420
ctggaactga ttaaacgcat ggaaatcttt ctgaatgccg gtgttacctt gtatgtttat 480
gaatttggtg gcattgggtg cagcgggtgat ctggttccgc tgagctatat taccggtagc 540
ctgattggcc tggaccgag ctttaaagtt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactgc gtcagctgaa tctgagtccg ctgaccctgc tgccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcat gcaactggata ttcaggcact gaatggtaca 780
aatcagagct ttcattccgt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgattagcct gctggccaat agccagctgg ttcgtgatga actggatggt 900
aaacatgatt atcgtgatca tgaactgatc caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaaat cgaaattgag 1020
attaacagcg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080
ggtaattttc tgggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcggt 1140
ctgctggcaa aacatctgga tgttcagatt gcaactgctg catcaccgga atttagcaat 1200
ggctctgcctc cgagtctgct gggtaatcgt gaacgtaaag ttaatatggg tctgaaaggt 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacagttt aaccagaata ttaacagcca gggttatacc 1380
agcgcaaccc tggcacgtcg tagcgttgat atttttcaga attatgttgc cattgccctg 1440
```

```

atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcctgtc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttggttgg 1560
cagaaaccga cctcagatcg tccgtatatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtggtg ttattgttca ggccgttcag 1680
gacattctgc cgtgtctgca t 1701

```

<210> 2

<211> 567

<212> PRT

<213> *Anabaena variabilis* PAL

<220>

<223> *Anabaena variabilis* PAL

<400> 2

```

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

```

Arg	Asp	His	Glu	Leu	Ile	Gln	Asp	Arg	Tyr	Ser	Leu	Arg	Cys	Leu	Pro
305					310					315					320
Gln	Tyr	Leu	Gly	Pro	Ile	Val	Asp	Gly	Ile	Ser	Gln	Ile	Ala	Lys	Gln
				325					330					335	
Ile	Glu	Ile	Glu	Ile	Asn	Ser	Val	Thr	Asp	Asn	Pro	Leu	Ile	Asp	Val
			340					345					350		
Asp	Asn	Gln	Ala	Ser	Tyr	His	Gly	Gly	Asn	Phe	Leu	Gly	Gln	Tyr	Val
		355					360					365			
Gly	Met	Gly	Met	Asp	His	Leu	Arg	Tyr	Tyr	Ile	Gly	Leu	Leu	Ala	Lys
	370					375					380				
His	Leu	Asp	Val	Gln	Ile	Ala	Leu	Leu	Ala	Ser	Pro	Glu	Phe	Ser	Asn
385					390					395					400
Gly	Leu	Pro	Pro	Ser	Leu	Leu	Gly	Asn	Arg	Glu	Arg	Lys	Val	Asn	Met
				405					410					415	
Gly	Leu	Lys	Gly	Leu	Gln	Ile	Cys	Gly	Asn	Ser	Ile	Met	Pro	Leu	Leu
			420					425					430		
Thr	Phe	Tyr	Gly	Asn	Ser	Ile	Ala	Asp	Arg	Phe	Pro	Thr	His	Ala	Glu
		435					440					445			
Gln	Phe	Asn	Gln	Asn	Ile	Asn	Ser	Gln	Gly	Tyr	Thr	Ser	Ala	Thr	Leu
	450					455					460				
Ala	Arg	Arg	Ser	Val	Asp	Ile	Phe	Gln	Asn	Tyr	Val	Ala	Ile	Ala	Leu
465					470					475					480
Met	Phe	Gly	Val	Gln	Ala	Val	Asp	Leu	Arg	Thr	Tyr	Lys	Lys	Thr	Gly
				485					490					495	
His	Tyr	Asp	Ala	Arg	Ala	Cys	Leu	Ser	Pro	Ala	Thr	Glu	Arg	Leu	Tyr
			500					505				510			
Ser	Ala	Val	Arg	His	Val	Val	Gly	Gln	Lys	Pro	Thr	Ser	Asp	Arg	Pro
		515					520					525			
Tyr	Ile	Trp	Asn	Asp	Asn	Glu	Gln	Gly	Leu	Asp	Glu	His	Ile	Ala	Arg
	530					535					540				
Ile	Ser	Ala	Asp	Ile	Ala	Ala	Gly	Gly	Val	Ile	Val	Gln	Ala	Val	Gln
545					550					555					560
Asp	Ile	Leu	Pro	Cys	Leu	His									
				565											

<210> 3

<211> 1701

<212> DNA

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 3

```

atgaaaaccc tgagtcaggc acagagcaaa accagcagcc agcagtttag ccataccggc 60
aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgtagct 120
gttgcccgta atggcaccgc ggttagcctg accaataata aagatattct gcagcgtatt 180
caggccagct gtgattatat caataatgca gttgaaaaag gtgaaccgat ttatgggtgtt 240
accagcggtt ttgggtggtat ggcaaatggt gtaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaaat agccacatgc gtggtgcaag cggtattcgt 420
ctggaactga ttaaacgcat ggaaatcttt ctgaatgccg gtgttaccct gtatgtttat 480
gaatttggtg gcattgggtg cagcgggtgat ctggttccgc tgagctatat taccggtagc 540

```

```

ctgattggcc tggacccgag ctttaaagtt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactgc gtcagctgaa tctgagtccg ctgaccctgc agccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcac gactggata ttcaggcact gaatggtaca 780
aatcagagct ttcatccgtt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgattagcct gctggccggt agccagctgg ttcgtgatga actggatggt 900
aaacatgatt atatggatgg tgaactgata caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaat cgaaattgag 1020
attaacacg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080
ggtaattttc tgggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcggt 1140
ctgctggcaa aacatctgga tgttcagatt gcactgctgg catcaccgga atttagcaat 1200
ggtctgcctc cgagtctggt gggtaatcgt gaacgtaaag ttaatatggg tctgaaaggt 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacagttt aaccagaata ttaacagcca gggttatacc 1380
agcgcaaccc tggcacgtcg tagcgttgat atttttcaga attatgttgc cattgccctg 1440
atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcccagc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttggtggt 1560
aaaaaaccga gctcagatcg tccgtatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtggtg ttattgttca ggccgttcag 1680
gacattctgc cgccgctgca t 1701

```

<210> 4

<211> 567

<212> PRT

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 4

```

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

```


<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 5

```
atgaaaaccc tgagtcaggc acagagcaaa accagcagcc agcagtttag ccataccggc 60
aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgtagct 120
gttgcccgta atggcaccgc ggtagcctg accaataata aagatattct gcagcgtatt 180
caggccagct gtgattatat caataatgca gttgaaaaag gtgaaccgat ttatggtggt 240
accagcgggt ttggtgggtat ggcaaatggt gtaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaaat agccacatgc gtggtgcaag cggtagctgt 420
ctggaactga ttaaaccgat ggaaatcttt ctgaatgccg gtgttacccc gtatgtttat 480
gaatttggtg gcattgggtg cagcgggtat ctggttccgc tgagctatat taccggtagc 540
ctgattggcc tggaccgag ctttaaagtt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactgc gtcagctgaa tctgagtccg ctgaccctgc agccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcat gactggata ttcaggcact gaatggtaca 780
aatcagagct ttcattccgtt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgattagcct gctggccggg agccagctgg ttcgtgatga actggatggg 900
aaacatgatt atatggatgg tgaactgac caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaat cgaaattgag 1020
attaacagcg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080
ggtaattttc tgggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcggt 1140
ctgctggcaa aacatctgga tgttcagatt gcactgctgg catcaccgga atttagcaat 1200
ggtctgcctc cgagtctggt gggtaatcgt gaacgtaaag ttaatatggg tctgaaagg 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacaggca aaccagaata ttaacagcca gggttatacc 1380
agcgcaaccc tggcacgtcg tagcgttgat atttttcaga attatgttgc cattgccctg 1440
atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcccagc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttggtggt 1560
aaaaaacgca gtcagatcg tccgtatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtggtg ttattgttca ggccgttcag 1680
gacattctgc cgccgctgca t 1701
```

<210> 6

<211> 567

<212> PRT

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 6

```
Met Lys Thr Leu Ser Gln Ala Gln Ser Lys Thr Ser Ser Gln Gln Phe
1           5           10          15
Ser His Thr Gly Asn Ser Ser Ala Asn Val Ile Ile Gly Asn Gln Lys
          20          25          30
Leu Thr Ile Asn Asp Val Val Arg Val Ala Arg Asn Gly Thr Ala Val
          35          40          45
Ser Leu Thr Asn Asn Lys Asp Ile Leu Gln Arg Ile Gln Ala Ser Cys
          50          55          60
```

Asp	Tyr	Ile	Asn	Asn	Ala	Val	Glu	Lys	Gly	Glu	Pro	Ile	Tyr	Gly	Val	65	70	75	80
Thr	Ser	Gly	Phe	Gly	Gly	Met	Ala	Asn	Val	Val	Ile	Ser	Arg	Glu	Gln		85	90	95
Ala	Ser	Glu	Leu	Gln	Thr	Asn	Leu	Val	Trp	Phe	Leu	Lys	Thr	Gly	Ala	100	105	110	
Gly	Asn	Lys	Leu	Pro	Leu	Ala	Asp	Val	Arg	Ala	Ala	Met	Leu	Leu	Arg	115	120	125	
Ala	Asn	Ser	His	Met	Arg	Gly	Ala	Ser	Gly	Ile	Arg	Leu	Glu	Leu	Ile	130	135	140	
Lys	Arg	Met	Glu	Ile	Phe	Leu	Asn	Ala	Gly	Val	Thr	Pro	Tyr	Val	Tyr	145	150	155	160
Glu	Phe	Gly	Ser	Ile	Gly	Ala	Ser	Gly	Asp	Leu	Val	Pro	Leu	Ser	Tyr	165	170	175	
Ile	Thr	Gly	Ser	Leu	Ile	Gly	Leu	Asp	Pro	Ser	Phe	Lys	Val	Asp	Phe	180	185	190	
Asn	Gly	Lys	Glu	Met	Asp	Ala	Pro	Thr	Ala	Leu	Arg	Gln	Leu	Asn	Leu	195	200	205	
Ser	Pro	Leu	Thr	Leu	Gln	Pro	Lys	Glu	Gly	Leu	Ala	Met	Met	Asn	Gly	210	215	220	
Thr	Ser	Val	Met	Thr	Gly	Ile	Ala	Ala	Asn	Cys	Val	Tyr	Asp	Thr	Gln	225	230	235	240
Ile	Leu	Thr	Ala	Ile	Ala	Met	Gly	Val	His	Ala	Leu	Asp	Ile	Gln	Ala	245	250	255	
Leu	Asn	Gly	Thr	Asn	Gln	Ser	Phe	His	Pro	Phe	Ile	His	Asn	Ser	Lys	260	265	270	
Pro	His	Pro	Gly	Gln	Leu	Trp	Ala	Ala	Asp	Gln	Met	Ile	Ser	Leu	Leu	275	280	285	
Ala	Gly	Ser	Gln	Leu	Val	Arg	Asp	Glu	Leu	Asp	Gly	Lys	His	Asp	Tyr	290	295	300	
Met	Asp	Gly	Glu	Leu	Ile	Gln	Asp	Arg	Tyr	Ser	Leu	Arg	Cys	Leu	Pro	305	310	315	320
Gln	Tyr	Leu	Gly	Pro	Ile	Val	Asp	Gly	Ile	Ser	Gln	Ile	Ala	Lys	Gln	325	330	335	
Ile	Glu	Ile	Glu	Ile	Asn	Ser	Val	Thr	Asp	Asn	Pro	Leu	Ile	Asp	Val	340	345	350	
Asp	Asn	Gln	Ala	Ser	Tyr	His	Gly	Gly	Asn	Phe	Leu	Gly	Gln	Tyr	Val	355	360	365	
Gly	Met	Gly	Met	Asp	His	Leu	Arg	Tyr	Tyr	Ile	Gly	Leu	Leu	Ala	Lys	370	375	380	
His	Leu	Asp	Val	Gln	Ile	Ala	Leu	Leu	Ala	Ser	Pro	Glu	Phe	Ser	Asn	385	390	395	400
Gly	Leu	Pro	Pro	Ser	Leu	Val	Gly	Asn	Arg	Glu	Arg	Lys	Val	Asn	Met	405	410	415	
Gly	Leu	Lys	Gly	Leu	Gln	Ile	Cys	Gly	Asn	Ser	Ile	Met	Pro	Leu	Leu	420	425	430	
Thr	Phe	Tyr	Gly	Asn	Ser	Ile	Ala	Asp	Arg	Phe	Pro	Thr	His	Ala	Glu	435	440	445	
Gln	Ala	Asn	Gln	Asn	Ile	Asn	Ser	Gln	Gly	Tyr	Thr	Ser	Ala	Thr	Leu	450	455	460	
Ala	Arg	Arg	Ser	Val	Asp	Ile	Phe	Gln	Asn	Tyr	Val	Ala	Ile	Ala	Leu	465	470	475	480
Met	Phe	Gly	Val	Gln	Ala	Val	Asp	Leu	Arg	Thr	Tyr	Lys	Lys	Thr	Gly	485	490	495	

His	Tyr	Asp	Ala	Arg	Ala	Gln	Leu	Ser	Pro	Ala	Thr	Glu	Arg	Leu	Tyr
			500					505					510		
Ser	Ala	Val	Arg	His	Val	Val	Gly	Lys	Lys	Pro	Ser	Ser	Asp	Arg	Pro
		515					520					525			
Tyr	Ile	Trp	Asn	Asp	Asn	Glu	Gln	Gly	Leu	Asp	Glu	His	Ile	Ala	Arg
	530					535					540				
Ile	Ser	Ala	Asp	Ile	Ala	Ala	Gly	Gly	Val	Ile	Val	Gln	Ala	Val	Gln
545					550					555					560
Asp	Ile	Leu	Pro	Pro	Leu	His									
					565										

<210> 7

<211> 1701

<212> DNA

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 7

```

atgaaaaccc tgagtcaggc acagagcaaa accagcagcc agcagtctag ccataccggc 60
aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgtacgt 120
gttgcccgtg atggcaccgc ggtagcctg accaataata aagatattct gcagcgtatt 180
caggccagct gtgattatat caataatgca gttgaaaaag gtgaaccgat ttatggtggt 240
accagcgggt ttggtggtat ggcaaatgtt gtaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaa atagccacatgc gtggtgcaag cggtattcgt 420
ctggaactga ttaaaccgat ggaaatcttt ctgaatgccg gtgttacccc gtatgtttat 480
gaatttggtg gcattggtgc cagcggtagt ctggttccgc tgagctatat taccggtagc 540
ctgattggcc tggaccgag ctttaaagtt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactgc gtcagctgaa tctgagtccg ctgaccctgc agccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcat gactggata ttcaggcact gaatggtaca 780
aatcagagct ttcattccgtt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgattagcct gctggccggg agccagctgg ttcgtgatga actggatggg 900
aaacatgatt atatggatgg tgaactgac caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaat cgaaattgag 1020
attaacagcg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080
ggtaattttc tgggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcggt 1140
ctgctggcaa aacatctgga tgttcagatt gcactgctgg catcaccgga atttagcaat 1200
ggtctgcctc cgagtctggt gggtaatcgt gaacgtaaag ttaatatggg tctgaaagg 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacaggca aaccagaata ttaacagcca gggttatacc 1380
agcgcaaccc tggcacgtcg tagcgttgat atttttcaga attatgttgc cattgccctg 1440
atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcccagc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttgttggt 1560
aaaaaaccca gctcagatcg tccgtatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtgggt ttattgttca ggccgttcag 1680
gacattctgc cgccgctgca t

```

<210> 8

<211> 567

<212> PRT

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 8

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

370	375	380
His Leu Asp Val Gln Ile	Ala Leu Leu Ala Ser	Pro Glu Phe Ser Asn
385	390	395
Gly Leu Pro Pro Ser Leu	Val Gly Asn Arg Glu	Arg Lys Val Asn Met
405	410	415
Gly Leu Lys Gly Leu Gln	Ile Cys Gly Asn Ser	Ile Met Pro Leu Leu
420	425	430
Thr Phe Tyr Gly Asn Ser	Ile Ala Asp Arg Phe	Pro Thr His Ala Glu
435	440	445
Gln Ala Asn Gln Asn Ile	Asn Ser Gln Gly Tyr	Thr Ser Ala Thr Leu
450	455	460
Ala Arg Arg Ser Val Asp	Ile Phe Gln Asn Tyr	Val Ala Ile Ala Leu
465	470	475
Met Phe Gly Val Gln Ala	Val Asp Leu Arg Thr	Tyr Lys Lys Thr Gly
485	490	495
His Tyr Asp Ala Arg Ala	Gln Leu Ser Pro Ala	Thr Glu Arg Leu Tyr
500	505	510
Ser Ala Val Arg His Val	Val Gly Lys Lys Pro	Ser Ser Asp Arg Pro
515	520	525
Tyr Ile Trp Asn Asp Asn	Glu Gln Gly Leu Asp	Glu His Ile Ala Arg
530	535	540
Ile Ser Ala Asp Ile Ala	Ala Gly Gly Val Ile	Val Gln Ala Val Gln
545	550	555
Asp Ile Leu Pro Pro Leu	His	
565		

<210> 9

<211> 1701

<212> DNA

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 9

```

atgaaaacc tgagtcaggc acagagcaaa accagcagcc agcagtctag ccataccggc 60
aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgtagct 120
gttgcccgtg atggcaccgc ggtagcctg accaataata aagatattct gcagcgtatt 180
caggccagct gtgattatat caataatgca gttgaaaaag gtgaaccgat ttatggtggt 240
accagcgggt ttggtggtat ggcaaatgtt gtaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaaat agccacatgc gtggtgcaag cggtattcgt 420
ctggaactga ttaaacgcat ggaaatcttt ctgaatgccg gtgttaccct gtatgtttat 480
gaatttggtg gcattgggtg cagcggtgat ctggttccgc tgagctatat taccggtagc 540
ctgattggcc tggaccgag ctttaaagtt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactga gacagctgaa tctgccgccg ctgaccctgc agccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcat gactggata ttcaggcact gaatggtaca 780
aatcagagct ttcattccgtt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgctaagcct gctggccggg agccagctgg ttcgtgatga actggatggg 900
aaacatgatt atatggatgg tgaactgata caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaaat cgaaattgag 1020
attaacagcg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080

```

```

ggtaattttc atggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcggt 1140
ctgctggcaa aacatctgga tgttcagatt gcactgctgg catcaccgga atttagcaat 1200
ggtctgcctc cgagtctggt gggtaatcgt gaacgtaaag ttaatatggg tctgaaaggt 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacaggca aaccagaata ttaacagcca gggttataacc 1380
agcgcaaccc tggcacgtcg tagcgttgaa atttttcaga attatgttgc cattgccctg 1440
atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcccagc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttgttggt 1560
aaaaaaccga gtcagatcg tccgtatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtggtg ttattgttca ggccgttcag 1680
gacattctgc cgccgctgca t                                     1701

```

<210> 10

<211> 567

<212> PRT

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 10

```

Met Lys Thr Leu Ser Gln Ala Gln Ser Lys Thr Ser Ser Gln Gln Ser
1          5          10          15
Ser His Thr Gly Asn Ser Ser Ala Asn Val Ile Ile Gly Asn Gln Lys
20        25        30
Leu Thr Ile Asn Asp Val Val Arg Val Ala Arg Asn Gly Thr Ala Val
35        40        45
Ser Leu Thr Asn Asn Lys Asp Ile Leu Gln Arg Ile Gln Ala Ser Cys
50        55        60
Asp Tyr Ile Asn Asn Ala Val Glu Lys Gly Glu Pro Ile Tyr Gly Val
65        70        75        80
Thr Ser Gly Phe Gly Gly Met Ala Asn Val Val Ile Ser Arg Glu Gln
85        90        95
Ala Ser Glu Leu Gln Thr Asn Leu Val Trp Phe Leu Lys Thr Gly Ala
100       105       110
Gly Asn Lys Leu Pro Leu Ala Asp Val Arg Ala Ala Met Leu Leu Arg
115       120       125
Ala Asn Ser His Met Arg Gly Ala Ser Gly Ile Arg Leu Glu Leu Ile
130       135       140
Lys Arg Met Glu Ile Phe Leu Asn Ala Gly Val Thr Pro Tyr Val Tyr
145       150       155       160
Glu Phe Gly Ser Ile Gly Ala Ser Gly Asp Leu Val Pro Leu Ser Tyr
165       170       175
Ile Thr Gly Ser Leu Ile Gly Leu Asp Pro Ser Phe Lys Val Asp Phe
180       185       190
Asn Gly Lys Glu Met Asp Ala Pro Thr Ala Leu Arg Gln Leu Asn Leu
195       200       205
Pro Pro Leu Thr Leu Gln Pro Lys Glu Gly Leu Ala Met Met Asn Gly
210       215       220
Thr Ser Val Met Thr Gly Ile Ala Ala Asn Cys Val Tyr Asp Thr Gln
225       230       235       240
Ile Leu Thr Ala Ile Ala Met Gly Val His Ala Leu Asp Ile Gln Ala
245       250       255

```

Leu Asn Gly Thr Asn Gln Ser Phe His Pro Phe Ile His Asn Ser Lys
 260 265 270
 Pro His Pro Gly Gln Leu Trp Ala Ala Asp Gln Met Leu Ser Leu Leu
 275 280 285
 Ala Gly Ser Gln Leu Val Arg Asp Glu Leu Asp Gly Lys His Asp Tyr
 290 295 300
 Met Asp Gly Glu Leu Ile Gln Asp Arg Tyr Ser Leu Arg Cys Leu Pro
 305 310 315 320
 Gln Tyr Leu Gly Pro Ile Val Asp Gly Ile Ser Gln Ile Ala Lys Gln
 325 330 335
 Ile Glu Ile Glu Ile Asn Ser Val Thr Asp Asn Pro Leu Ile Asp Val
 340 345 350
 Asp Asn Gln Ala Ser Tyr His Gly Gly Asn Phe His Gly Gln Tyr Val
 355 360 365
 Gly Met Gly Met Asp His Leu Arg Tyr Tyr Ile Gly Leu Leu Ala Lys
 370 375 380
 His Leu Asp Val Gln Ile Ala Leu Leu Ala Ser Pro Glu Phe Ser Asn
 385 390 395 400
 Gly Leu Pro Pro Ser Leu Val Gly Asn Arg Glu Arg Lys Val Asn Met
 405 410 415
 Gly Leu Lys Gly Leu Gln Ile Cys Gly Asn Ser Ile Met Pro Leu Leu
 420 425 430
 Thr Phe Tyr Gly Asn Ser Ile Ala Asp Arg Phe Pro Thr His Ala Glu
 435 440 445
 Gln Ala Asn Gln Asn Ile Asn Ser Gln Gly Tyr Thr Ser Ala Thr Leu
 450 455 460
 Ala Arg Arg Ser Val Glu Ile Phe Gln Asn Tyr Val Ala Ile Ala Leu
 465 470 475 480
 Met Phe Gly Val Gln Ala Val Asp Leu Arg Thr Tyr Lys Lys Thr Gly
 485 490 495
 His Tyr Asp Ala Arg Ala Gln Leu Ser Pro Ala Thr Glu Arg Leu Tyr
 500 505 510
 Ser Ala Val Arg His Val Val Gly Lys Lys Pro Ser Ser Asp Arg Pro
 515 520 525
 Tyr Ile Trp Asn Asp Asn Glu Gln Gly Leu Asp Glu His Ile Ala Arg
 530 535 540
 Ile Ser Ala Asp Ile Ala Ala Gly Gly Val Ile Val Gln Ala Val Gln
 545 550 555 560
 Asp Ile Leu Pro Pro Leu His
 565

<210> 11

<211> 1701

<212> DNA

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 11

atgaaaaccc tgagtcaggc tcagagcaaa accagcagcc agcagtctag ccataccggc 60
 aatagcagcg caaatgtgat tattggtaat cagaaactga ccatcaatga tgttgtagct 120
 gttgcccgtg atggcaccgc ggtagcctg accaataata aagatattct gcagcgtatt 180

```

caggccagct gtgattatat caataatgca gttgaaaaag gtgaaccgat ttatggtggt 240
accagcgggt ttggtggtat ggcaaatgtt gtaattagcc gtgaacaggc aagcgaactg 300
cagaccaatc tggtttggtt tctgaaaacc ggtgcaggta ataaactgcc gctggcagat 360
gttcgtgcag caatgctgct gcgtgcaaag agccacatgc gtggtgcaag cggttattcgt 420
ctggaactga ttaaacgcat ggaaatcttt ctgaatgccg gtgttacccc gtatgtttat 480
gaatttggtg gcattggtgc cagcgggtgat ctggttccgc tgagctatat taccggtagc 540
ctgattggcc tggacccgag ctttaaagt gattttaatg gcaaagaaat ggacgcaccg 600
accgcactga gacagctgaa tctgccgccg ctgaccctgc agccgaaaga aggtctggca 660
atgatgaatg gcaccagcgt tatgaccggt attgcagcaa attgtgttta tgataccag 720
attctgaccg caattgcaat ggggtgttcat gactggata ttcaggcact gaatggtaca 780
aatcagagct ttcattcgtt tatccataac agcaaaccgc atccgggtca gctgtgggca 840
gcagatcaga tgctaagcct gctggccggg agccagctgg ttcgtgatga actggatggt 900
aaacatgatt atatggatgg tgaactgac caggatcggt atagcctgcg ttgtctgccg 960
cagtatctgg gtccgattgt tgatggtatt agccagattg ccaaacaat cgaaattgag 1020
attaacagcg ttaccgataa cccgctgatt gatgttgata atcaggcaag ctatcatggt 1080
ggtaattttc atggtcagta tgttggtatg ggtatggatc atctgcgcta ttatatcgg 1140
ctgctggcaa aacatctgga tgttcagatt gactgctgg catcaccgga atttagcaat 1200
ggctctgcctc cgagtctggt gggtaatcgt gaacgtaaag ttaatatggg tctgaaagg 1260
ctgcagattt gcggtaatag cattatgccg ctgctgacct tttatggtaa tagtattgca 1320
gatcgttttc cgacccatgc cgaacaggca aaccagaata ttaacagcca gggttatacc 1380
agcgcaaccc tggcacgtcg tagcgttgaa atttttcaga attatgttgc cattgccctg 1440
atgtttggtg ttcaggcagt tgatctgcgt acctacaaaa aaaccggtca ttatgatgca 1500
cgtgcccagc tgtcaccggc aaccgaacgt ctgtatagcg cagttcgtca tgttggtggt 1560
aaaaaaccga gtcagatcg tccgtatatt tggaatgata atgaacaggg tctggatgaa 1620
catattgcac gtattagtgc agatattgca gccggtggtg ttattgttca ggccgttcag 1680
gacattctgc cgccgctgca t 1701

```

<210> 12

<211> 567

<212> PRT

<213> Artificial Sequence

<220>

<223> Variant of PAL from *Anabaena variabilis*

<400> 12

```

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

```

130		135		140
Lys Arg Met Glu Ile Phe Leu Asn Ala Gly Val Thr Pro Tyr Val Tyr				
145		150		155
Glu Phe Gly Ser Ile Gly Ala Ser Gly Asp Leu Val Pro Leu Ser Tyr				
	165		170	
Ile Thr Gly Ser Leu Ile Gly Leu Asp Pro Ser Phe Lys Val Asp Phe				
	180		185	
Asn Gly Lys Glu Met Asp Ala Pro Thr Ala Leu Arg Gln Leu Asn Leu				
	195		200	
Pro Pro Leu Thr Leu Gln Pro Lys Glu Gly Leu Ala Met Met Asn Gly				
	210		215	
Thr Ser Val Met Thr Gly Ile Ala Ala Asn Cys Val Tyr Asp Thr Gln				
225		230		235
Ile Leu Thr Ala Ile Ala Met Gly Val His Ala Leu Asp Ile Gln Ala				
	245		250	
Leu Asn Gly Thr Asn Gln Ser Phe His Pro Phe Ile His Asn Ser Lys				
	260		265	
Pro His Pro Gly Gln Leu Trp Ala Ala Asp Gln Met Leu Ser Leu Leu				
	275		280	
Ala Gly Ser Gln Leu Val Arg Asp Glu Leu Asp Gly Lys His Asp Tyr				
	290		295	
Met Asp Gly Glu Leu Ile Gln Asp Arg Tyr Ser Leu Arg Cys Leu Pro				
305		310		315
Gln Tyr Leu Gly Pro Ile Val Asp Gly Ile Ser Gln Ile Ala Lys Gln				
	325		330	
Ile Glu Ile Glu Ile Asn Ser Val Thr Asp Asn Pro Leu Ile Asp Val				
	340		345	
Asp Asn Gln Ala Ser Tyr His Gly Gly Asn Phe His Gly Gln Tyr Val				
	355		360	
Gly Met Gly Met Asp His Leu Arg Tyr Tyr Ile Gly Leu Leu Ala Lys				
	370		375	
His Leu Asp Val Gln Ile Ala Leu Leu Ala Ser Pro Glu Phe Ser Asn				
385		390		395
Gly Leu Pro Pro Ser Leu Val Gly Asn Arg Glu Arg Lys Val Asn Met				
	405		410	
Gly Leu Lys Gly Leu Gln Ile Cys Gly Asn Ser Ile Met Pro Leu Leu				
	420		425	
Thr Phe Tyr Gly Asn Ser Ile Ala Asp Arg Phe Pro Thr His Ala Glu				
	435		440	
Gln Ala Asn Gln Asn Ile Asn Ser Gln Gly Tyr Thr Ser Ala Thr Leu				
	450		455	
Ala Arg Arg Ser Val Glu Ile Phe Gln Asn Tyr Val Ala Ile Ala Leu				
465		470		475
Met Phe Gly Val Gln Ala Val Asp Leu Arg Thr Tyr Lys Lys Thr Gly				
	485		490	
His Tyr Asp Ala Arg Ala Gln Leu Ser Pro Ala Thr Glu Arg Leu Tyr				
	500		505	
Ser Ala Val Arg His Val Val Gly Lys Lys Pro Ser Ser Asp Arg Pro				
	515		520	
Tyr Ile Trp Asn Asp Asn Glu Gln Gly Leu Asp Glu His Ile Ala Arg				
	530		535	
Ile Ser Ala Asp Ile Ala Ala Gly Gly Val Ile Val Gln Ala Val Gln				
545		550		555
Asp Ile Leu Pro Pro Leu His				560

