

43961-0002W01
SEQUENCE LISTING

dhaB1 SEQ ID NO: 1

ATGAAAAGATCAAAACGATTTGCAGTACTGGCCCAGCGCCCCGTCAATCAGGACGG
GCTGATTGGCGAGTGGCCTGAAGAGGGGGCTGATCGCCATGGACAGCCCCTTTGACC
CGGTCTCTTCAGTAAAAGTGGACAACGGTCTGATCGTCGAGCTGGACGGCAAACGC
CGGGACCAGTTTGACATGATCGACCGATTTATCGCCGATTACGCGATCAACGTTGAG
CGCACAGAGCAGGCAATGCGCCTGGAGGCGGTGGAAATAGCCCGCATGCTGGTGGA
TATTCACGTCAGTCGGGAGGAGATCATTGCCATCACTACCGCCATCACGCCGGCCAA
AGCGGTTCGAGGTGATGGCGCAGATGAACGTGGTGGAGATGATGATGGCGCTGCAGA
AGATGCGTGCCCCGCCGACCCCCCTCCAACCAGTGCCACGTCACCAATCTCAAAGAT
AATCCGGTGCAGATTGCTGCTGACGCCGCCGAGGCCGGGATCCGCGGCTTCTCAGA
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AAAACCTGATCGCCTCTATGCTCGACCTCGAAGTGGCGTCCGCCAACGACCAGACTT
TCTCCCACTCGGATATTCGCCGCACCGCGCGCACCTGATGCAGATGCTGCCGGGCA
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GCTCGAACTTCGATGCGGAAGATTTTGATGATTACAACATCCTGCAGCGTGACCTGA
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CGACGAGGAGGTGGAGGCCGCCACCTACGCGCACGGTAGCAACGAGATGCCGCCGC
GTAACGTGGTGGAGGATCTGAGTGCGGTGGAAGAGATGATGAAGCGCAACATCACC
GGCCTCGATATTGTCGGCGCGCTGAGCCGCAGCGGCTTTGAGGATATCGCCAGCAAT
ATTCTCAATATGCTGCGCCAGCGGGTCACCGGCGATTACCTGCAGACCTCGGCCATT
CTCGATCGGCAGTTCGAGGTGGTGAAGTGCAGTCAACGACATCAATGACTATCAGGG
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CGGGCGTGGTTCAGCCCGACACCATTGAATAA

dhaB2 SEQ ID NO: 2

ATGCAACAGACAACCCAAATTCAGCCCTCTTTTACCCTGAAAACCCGCGAGGGCGG
GGTAGCTTCTGCCGATGAACGCGCCGATGAAGTGGTGAATCGGCGTCGGCCCTGCCTT
CGATAAACACCAGCATCACACTCTGATCGATATGCCCCATGGCGCGATCCTCAAAG
AGCTGATTGCCGGGGTGGAAGAAGAGGGGCTTCACGCCCCGGGTGGTGCGCATTCTG
CGCACGTCCGACGTCTCCTTTATGGCCTGGGATGCGGCCAACCTGAGCGGCTCGGGG
ATCGGCATCGGTATCCAGTCGAAGGGGACCACGGTCATCCATCAGCGCGATCTGCT
GCCGCTCAGCAACCTGGAGCTGTTCTCCAGGCGCCGCTGCTGACGCTGGAAACCTA
CCGGCAGATTGGCAAAAACGCCGCGCGCTATGCGCGCAAAGAGTCACCTTCGCCGG
TGCCGGTGGTGAACGATCAGATGGTGCGGCCGAAATTTATGGCCAAAGCCGCGCTA
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>dhaB3 SEQ ID NO: 3

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GCATATCCTGACGCCTACCGGCAAACCATTGACCGATATTACCCTCGAGAAGGTGCT
CTCTGGCGAGGTGGGCCCCGCAGGATGTGCGGATCTCCTGCCAGACCCCTTGAGTACCA
GGCGCAGATTGCCGAGCAGATGCAGCGCCATGCGGTGGCGCGCAATTTCCGCCGCG
CGGCGGAGCTTATCGCCATTCTGACGAGCGCATTCTGGCTATCTATAACGCGCTGC
GCCCCGTTCCGCTCCTCGCAGGCGGAGCTGCTGGCGATCGCCGACGAGCTGGAGCAC
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>gdrA SEQ ID NO: 4

ATGCCGTTAATAGCCGGGATTGATATCGGCAACGCCACCACCGAGGTGGCGCTGGC
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CTGGCGAAAACACCGTGGTCGATGAGCGATGTCTCTCGCATCTATCTTAACGAAGCC
GCGCCGGTGATTGGCGATGTGGCGATGGAGACCATCACCGAGACCATTATCACCGA
ATCGACCATGATCGGTCATAACCCGCAGACGCCGGGGCGGGGTGGGCGTTGGCGTGG
GGACGACTATCGCCCTCGGGCGGCTGGCGACGCTGCCGGCGGGCGCAGTATGCCGAG
GGGTGGATCGTACTGATTGACGACGCCGTCGATTTCTTGACGCCGTGTGGTGGCTC
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CGGCGTGCTGGTGAACAACCGCCTGCGTAAAACCCTGCCGGTGGTAGATGAAGTGA
CGCTGCTGGAGCAGGTCCCCGAGGGGGTAATGGCGGGCGGTGGAAGTGGCCGCGCCG
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AGCCCCGAAGAGACCCAGGCCATCGTCCCCATCGCCCGCGCCCTGATTGGCAACCG
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GGCGCGGAAGCCATCATGCAGGCGATGAGCGCCTGCGCTCCGGTACGCGACATCCG
CGGCGAACCGGGCACTCACGCCGGCGGCATGCTTGAGCGGGTGCGCAAGGTAATGG
CGTCCCTGACCGACCATGAGATGAGCGCGATATACATCCAGGATCTGCTGGCGGTG
GATACGTTTATTCCGCGCAAggtgcagggcGGGATGGCCGGCGAGTGCGCCATGGAAAAT
GCCGTCGGGATGGCGGCGATGGTGAAAGCGGATCGTCTGCAAATGCAGGTTATCGC
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GCTGGGCCTCGAGGATCTTTGCTGGCGGAAGCGATAAAAAAATACCCGCTGGCCA
AAGTGGAAGAGCCTGTTTCAGTATTCGTCACGAGAATGGCGCGGTGGAGTTCTTTCCGG
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GTGCCGATCGATAACGCCAGCCCGCTGGAAAAAATTCGTCTCGTGCGCCGGCAGGC
GAAAGAGAAAGTGTTTGTACCAACTGCCTGCGCGCGCTGCGCCAGGTCTCACCCG
GCGGTTCCATTCGCGATATCGCCTTTGTGGTGTGGTGGGCGGCTCATCGCTGGACT
TTGAGATCCCGCAGCTTATCACGGAAGCCTTGTCGCACTATGGCGTGGTGCCTGGG
AGGGCAATATTCGGGGAACAGAAGGGCCGCGCAATGCGGTGCGCACCGGGGCTGCTA
CTGGCCGGTCAAGGCGAATTAA

>gdrB SEQ ID NO: 5

ATGTCGCTTTCACCGCCAGGCGTACGCCTGTTTTACGATCCGCGCGGGCACCATGCC
GGCGCCATCAATGAGCTGTGCTGGGGGCTGGAGGAGCAGGGGGTCCCCTGCCAGAC
CATAACCTATGACGGAGGCGGTGACGCCGCTGCGCTGGGCGCCCTGGCGGCCAGAA
GCTCGCCCCCTGCGGGTGGGTATTGGGCTCAGCGCGTCCGGCGAGATAGCCCTCACTC
ATGCCCAGCTGCCGGCGGACGCGCCGCTGGCTACCGGACACGTCACCGATAGCGAC
GATCATCTGCGTACGCTCGGCGCCAACGCCGGGCAGCTGGTTAAAGTCCTGCCGTTA
AGTGAGAGAAACTGA

>kgsA SEQ ID NO: 6

ATGAGAGGATCGGGATCCGCTAACGTGACTTATACGGATACGCAACTGCTGATCGA
CGGTGAGTGGGTGACGCCGCGAGCGGCAAGACGATCGACGTCGTGAACCCGGCGA
CCGGCAAGCCGATCGGCAGGGTGGCCCATGCGGGCATCGCCGATCTCGACCGTGCG
CTCGCCGCCGCGCAAAGCGGCTTCGAGGCATGGCGCAAGGTGCCCGCGCACGAGCG
CGCGGCGACGATGCGCAAGGCGGCCGCGCTGGTGCGTGAACGCGCCGACGCGATCG
CGCAGCTGATGACGCAAGGAGCAGGGCAAGCCGCTCACCGAAGCGCGCGTCAAGTG
CTGTGCTCCGCGGACATCATCGAATGGTTCGCGGACGAAGGCCGCCGCGTGTACGG
CCGGATCGTGCCGCCGCGCAACCTCGGCGCACAGCAGACGGTTCGTGAAGGAGCCGG
TCGGCCCCGGTTCGCCGCGTTCACGCCGTGGAATTTCCCGGTCAACCAGGTTCGTGCGCA
AGCTGAGCGCCGCGCTGGCAACCGGCTGTTCTGTTCTCGTGAAAGCGCCGGAAGAA
ACCCCCGCGTCGCCGGCCGCGCTGCTGCGCGCCTTCGTCGACGCAAGGCGTGCCGGCC
GGCGTGATCGGCCTCGTGTACGGCGATCCGGCCGAAATCTCGTCGTACCTGATCCCCG
CACCCGGTGATCCGCAAGGTCACGTTACGGGTTTCGACGCCGGTTCGGCAAGCAGCT
CGCCTCGCTGGCGGGGcctgcacaTGAAGCGCGCGACGATGGAGCTGGGCGGGCACGCAC
CGGTGATCGTGGCCGAAGACGCCGACGTTGCGCTCGCGGTGGCAGCGGCCGGCGGC
GCGAAGTTCCGCAACGCGGGGCAGGTCTGCATCTCGCCGACGCGCTTCCTCGTGAC
AACAGCATCCGCGACGAATTCACGCGCGCGCTGGTCAAGCATGCCGAAGGGCTGAA
GGTCGGCAACGGCCTCGAGGAAGGCACGACGCTCGGCGCGCTCGCGAACCCGCGCC
GGCTGACCGCGATGGCGTCGGTCATCGACAACGCGCGCAAGGTCCGTGCGAGCATC
GAAACCGGCGGCGAGCGGATCGGCTCGGAAGGCAACTTCTTCGCGCCGACCGTGAT
CGCGAACGTGCCGCTCGATGCGGACGTGTTCAACAACGAGCCGTTTCGGCCCCGGTCG
CGGCGATTTCGCGGTTTCGACAAGCTCGAAGAGGCGATCGCGGAAGCGAACCGTTTG
CCGTTCCGTCTTGCCGGCTACGCGTTCACGCGTTCGTTTCGCGAACGTGCACCTGCTC
ACGCAGCGCCTCGAAGTCGGGATGCTGTGGATCAACCAGCCGCCGACTACATGGCC
GGAAATGCCGTTTCGGCGGCGTGAAGGACTCGGGCTACGGTTCGGAAGGCGGCCCGG
AAGCGCTCGAGCCGTACCTCGTCACGAAGTCGGTGACGGTAATGGCCGTCTGA

Inducible Promoters: PhbdH-1, PmmsA; PhbdH-4, PhpdH

SEQ ID NO: 11 PhbdH-4 (Pc4 on slide 3)

GCCCCCGCCTACCCGCCCCAGCCACCCCGGACTCAGCAAGGATGCTGGCCCCGGGCC
TGGGCGGAGACGTCTTTCGCGCCCGACCATCAGAACAAGAGGACAACCCC

SEQ ID NO: 12 PhpdH

TGTGGGAGCGGGCGTGCCCGCGAAGAGGCCAGCACAGACTTACCACTGTGCTAAAA
CGCACAGCGGCTGCGCGAAATCTCGTGTTTCTCCACGAAATTACTACTAAGATGG
ATCGGGACAAGAATAATAATCAGGCCCGAGGTTGCAC

SEQ ID NO: 13 PhbdH-1

TGCGTAATGCCCCACCGTTCTGCCAGGCAACGCGAAACCTGTAGGAGCGGCCTTGTG
TCGCGATGGGCTGCGCAGCAGCCCCGGCATTGTTTTGTCATCGATGCGGAGATCTGGGG
CTGCTGCGCAGCCCATCGCGACACAAGGCCGCTCCTACAGGTTCTGGCCCCGCATGG
GTAAAGTTCGAACCAGTCAGGAGTCATTG

SEQ ID NO: 14 PmmsA (Pcm from slide 2)

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCG

SEQ ID NO: 15 PmmsA delta 2 Figure 4

TTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATCCCG

SEQ ID NO: 16 O1 of MmsA operator

AATGTGCAAAAACGCAGACCATACTTGCACATCA

SEQ ID NO: 17 O2 of MmsA operator

CAAAAATGCACTGTTAGGATCGATCCAGACAAC

SEQ ID NO: 18 PmmsA and operator. Figure 4

GCACCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACA
TCAAAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGA
ATCCCG

SEQ ID NO: 19 PmmsA2a

TCCGATTTATGCGCCTCTAGAGGATCCCCGGGTACTAACATGTCAGCCTCAGCGCAC
CTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCAAT
CCTTGCTTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATCCC
G

SEQ ID NO: 20 PmmsA2b

TCCGATTTATGCGCCTCTAGAGGATCCCCGGGTACTAACATGTCAGCCTCAGCGCAC
CTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCAA
AAATGCACTGTTAGGATCGCGCCCAGGCACAAAAAAGCCACAGGCTGGGAGAATCC
CG

SEQ ID NO: 21 PmmsA2ab

TCCGATTTATGCGCCTCTAGAGGATCCCCGGGTACTAACATGTCAGCCTCAGCGCAC
CTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCAAT
CCTTGCTTGTTAGGATCGCGCCCAGGCACAAAAAAGCCACAGGCTGGGAGAATCCC
G

Constitutive promoter: Pzwf.

SEQ ID NO: 7 Pzwf

GGCGACCAACAACGGCGCGAGGTGGCAAAAATATCTTGTTTAATTACTACATATTTG
TCTTAATGCCGGCGTGTAAGGCTAACTATCGTTCAAATTTAGTTGGTAACAACAA

SEQ ID NO: 8 Pzwf-1

GGCGACCAACAACGGCGCGAGGTGGCAAAAACGGTTTGACACAGTAATTAAAAAG
ACGTATAATTGCGTTGTGTAAGGCTAACTATCGTTCAAATTTAGTTGGTAACAACA
A

SEQ ID NO: 61 Pzwf-1 shorter

ACGGTTTGACACAGTAATTAAAAAGACGTATAATTGCGTT

SEQ ID NO: 9 Pzwf-7 (the sequence for Pzwf-7 in the slide deck from 201700926 is
different than the sequence of Pzwf-7 on slide 4. MmsR overexpression from the 3-HP
patent.pptx; please confirm this is the accurate sequence.

GGCGACCAACAACGGCGCGAGGTGGCAAAAGTATATTGACATTCCATGCGAAGGTC
GTTATAATACAGTAGTGTAAGGCTAACTATCGTTCAAATTTAGTTGGTAACAACAA

SEQ ID NO: 62: Pzwf-7 shorter (F#9 on 2017000926)

GTATATTGACATTCCATGCGAAGGTCGTTATAATACAGTA

SEQ ID NO: 10 Pzwf-12

GGCGCGAGGTGGCAAAATAATCTTGACAACCTGGAGAGAATTGTGGTATAATGGGAG
CGTGTAAGGCTAACTATCGTTCAAATTTAGTTGGTAACAACAA

SEQ ID NO: 63 Pzwf-12 shorter

TAATCTTGACAACCTGGAGAGAATTGTGGTATAATGGGAGC

SEQ ID NO: 52 Pzwf #2

TCCACTTGACATACCCTAACATCGGGATTATAATGTCTGC

SEQ ID NO: 53 Pzwf #3

GTTGGTTGACATGGCGCTGTCGATCGGATATAATGTTTGT

SEQ ID NO: 54 Pzwf #4

GCGTCTTGACATCTTACTAGATTGTGCGTATAATAGTCGC

SEQ ID NO: 55 Pzwf #5

GGCGTTTGACATGTGGATGTAATCCTGTTATAATTTTTTA

SEQ ID NO: 56 Pzwf #6

GATCCTTGACAGCGAGGTATGAGTGAGGTATAATGTAACC

SEQ ID NO: 57 Pzwf #7

TGCGTTTGACAATTTGTTACGTTAGTGCTATAATCTAGTT

SEQ ID NO: 58 Pzwf #8

TACCCTTGACATAACGGCATTCTGGTGGTATAATCATGCC

SEQ ID NO: 59 Pzwf #10

GGGGGTTGACAACTGCGTGTCTGTCTGTTATAATATCCCG

SEQ ID NO: 60 Pzwf #11

GAGAATTGACAGATGACTTATTTTCGTTGAATTCCTGC

UTR design

SEQ ID NO: 22 UTR0

CGACGGCAAGCCCGTCGAGTCCACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 23 UTR1

CGACGGCAAGCCAACTGAACCCACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 24 UTR2

CGACGGCAAGCCCTAACTGGACACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 25 UTR3

CGACGGCAAGCCCTAACAGGACACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 26 UTR4

CGACGGCAAGCCCAAGCTGGACACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 27 UTR5

CGACGGCAAGCCCTAGCAGGACACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 28 UTR6

CGACGGCAAGCCCAAGCAGGACACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

SEQ ID NO: 64 UTR-PmmsA

CGACGGCAAGCCCGTCGAGTCCACCATGGCTAACGTGACTTACACCGATACCCAAC
TGCT

Opt – codon usage

SEQ ID NO: 29 Pcm-Best(kgsA) Opt1

ATGGCCAACGTGACCTACACCGACACCCAGCTGCTGATCGACGGC

SEQ ID NO: 30 Pcm-Same(kgsA) Opt3

ATGGCTAACGTGACTTACACCGATACCCAAGCTGCTGATCGACGGC

SEQ ID NO: 31 Pcm-medium(kgsA) Opt2

ATGGCGAACGTGACCTACACCGACACCCAGCTCCTGATCGACGGC

Fusion protein – 5, 10, 15, 20

SEQ ID NO: 32 Pcm-mmsA(5)

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCGATGACCGCAACTGCC

SEQ ID NO: 33 Pcm-mmsA(10)

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCGATGACCGCAACTGCCCCGACCGTCAAAGT

SEQ ID NO: 34 Pcm-mmsA(15)

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCGATGACCGCAACTGCCCCGACCGTCAAAGTTCCTCGACGGCAAG

SEQ ID NO: 35 Pcm-mmsA(20)

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCGATGACCGCAACTGCCCCGACCGTCAAAGTTCCTCGACGGCAAGCCCGTCGA
GTCCACC

B12 expression constructs

SEQ ID NO:36 Pedd promoter

GGCAGCATTCTCCTACAGACTATCAGTTGTTGTTTTTACAACATAATCTTCGAATACA
AAGCATTCTACTTTTCTTCGAAGCGGAAATTTAATGTTTTTTTACCACAACATAAGAAA
AGAGACGACCTTCATGACTATACGCCTGGCGATCAACGGGTTCGGCCGCATCGGTC
GGAATATCCTCCGTGCACTCTACTCCGGCCCCTACCGCCAGCACCTGCAGGTAGTGG
CGATCAACGACCTGGGCGATGCGGGCGATCAACGCCCACCTGTTGCAGTACGACAGC
GTGCACGGACGCTTCC

SEQ ID NO: 37 PsucA promoter

CCAAGGCAATCGGTACATCCGTAACATGCTGCTGCAGAGCGGCACTTGATCCGAG
GGCCTCGCGCCCAAAGATCATTGCAAGAGCGACACCTGTACCGCCGGAACATTGTC
CGGCGGTACAGTCCCTAGGACCCAAGCCACAAAGCGGGGGTCTGTTTTGAAAAC
GTATATATGACCAGCAGGGGCATCCGGGCTGGTACCGGACTATCTGCGGGGATCG

GTGGCTTGAAGTCGCTGTGTATGACTTCGCGCCAGAGATTCCACAGGTGGAGTCCCC
TTACCGAGGGTGACCAAGC

SEQ ID NO: 38 cobG-Pedd-PsucA-cobL (3-fold)

GACGGCAGCATTCTCCTACAGACTATCAGTTGTTGTTTTTACAACATAATCTTCGAAT
ACAAAGCATTACTTTTCTTCGAAGCGGAAATTTAATGTTTTTTACCACAACATAAG
AAAAGAGACGACCTTCATGACTATACGCCTGGCGATCAACGGGTTCGGCCGCATCG
GTCGGAATATCCTCCGTGCACTCTACTCCGGCCCCCTACCGCCAGCACCTGCAGGTAG
TGGCGATCAACGACCTGGGCGATGCGGCGATCAACGCCCACCTGTTGCAGTACGAC
AGCGTGACGACGCTTCCGTAGAGTTGCCAAGGCAATCGGTCACATCCGTAACAT
GCTGCTGCAGAGCGGCACTTGATCCGAGGGCCTCGCGCCCAAAGATCATTGCAAGA
GCGACACCTGTACCGCCGGAACATTGTCCGGCGGTACAGTCCCTAGGACCCAAAGCC
CACAAAGCGGGGGTCTGTTTTGAAAACGTATATATGACCAGCAGGGGCATCCGGG
CTGGTACCCGGACTATCTGCGGGGATCGGTGGCTTGAAGTCGCTGTGTATGACTTCG
CGCCAGAGATTCCACAGGTGGAGTCCCCTTACCGAGGGTGACCAAGCATG

SEQ ID NO: 39 Psp9

TTGTTGTTACCAACTAAATTTTGAACGATAGTTAGCCTTACACCGGGATATTATAAC
AGACAAACACGCAGTTGTCAACCCCC

SEQ ID NO: 40 Pzwf

GATGCTGAAGCGCGTGGCCTGCTGCGGGTTCGTGCAGGATCACTTCGGCGACCTTGCG
CTCGGCCTTGTTTCAGCTGTTCCAGACGGCTCTGGATCTGCTCCAGCAGGTTTTTCATC
CGTGCTCCTTGGGCAATCGACGGTTGGCCGGGTAGGGGCGGCCAGCGGCGCTATCC
TAACGTCAGGCCGGCAGGCGACCAACAACGGCGCGAGGTGGCAAAAATATCTTGTT
TAATTACTACATATTTGTCTTAATGCCGGCGTGTAAGGCTAACTATCGTTCAAAATTT
AGTTGGTAACAACAA

SEQ ID NO: 41 cobG-Psp9-Pzwf-cobL (5-fold)

CATTTGTTGTTACCAACTAAATTTTGAACGATAGTTAGCCTTACACCGGGATATTATA
ACAGACAAACACGCAGTTGTCAACCCCCTATGCGCAGCTAGAGATGCTGAAGCGCG
TGGCCTGCTGCGGGTTCGTGCAGGATCACTTCGGCGACCTTGCGCTCGGCCTTGTTCA
GCTGTTCCAGACGGCTCTGGATCTGCTCCAGCAGGTTTTTCATCCGTGCTCCTTGGGC
AATCGACGGTTGGCCGGGTAGGGGCGGCCAGCGGCGCTATCCTAACGTCAGGCCGG
CAGGCGACCAACAACGGCGCGAGGTGGCAAAAATATCTTGTTTAATTACTACATATT
TGTCTTAATGCCGGCGTGTAAGGCTAACTATCGTTCAAAATTTAGTTGGTAACAACA
AATG

SEQ ID NO: 42 Pzwf

TTGTTGTTACCAACTAAATTTTGAACGATAGTTAGCCTTACACGCCGGCATTAAAGAC
AAATATGTAGTAATTAAACAAGATATTTTTGCCACCTCGCGCCGTTGTTGGTCGCCT
GCCGGCCTGACGTTAGGATAGCGCCGCTGGCCGCCCTACCCGGCCAACCGTCGATT
GCCCAAGGAGCACGGATGAAAAACCTGCTGGAGCAGATCCAGAGCCGTCTGGAACA
GCTGAACAAGGCCGAGCGCAAGGTCGCCGAAGTGATCCTGCACGACCCGCAGCAGG
CCACGCGCTTCAGCATC

SEQ ID NO: 43 Psp9
GGGGGTTGACAACTGCGTGTGTTGTTATAATATCCCGGTGTAAGGCTAACTATC
GTTCAAAATTTAGTTGGTAACAACAA

SEQ ID NO: 44 cobW-Pzwf-Psp9-cbtB (3-fold)
CATTTGTTGTTACCAACTAAATTTTGAACGATAGTTAGCCTTACACGCCGGCATTAA
GACAAATATGTAGTAATTAACAAGATATTTTTGCCACCTCGCGCCGTTGTTGGTCG
CCTGCCGGCCTGACGTTAGGATAGCGCCGCTGGCCGCCCTACCCGGCCAACCGTCG
ATTGCCCAAGGAGCACGGATGAAAAACCTGCTGGAGCAGATCCAGAGCCGTCTGGA
ACAGCTGAACAAGGCCGAGCGCAAGGTCGCCGAAGTGATCCTGCACGACCCGCAGC
AGGCCACGCGCTTCAGCATCTCTAGCTGCGCATAGGGGGTTGACAACTGCGTGTGTTG
TCTGTTATAATATCCCGGTGTAAGGCTAACTATCGTTCAAAATTTAGTTGGTAACA
CAAATG

SEQ ID NO: 45 Pkt
Cgctgaatctcctgcgggggctgcttcgaaactcgaagggaatgaaaaaggccgggtatttgcgccagccggggccccgtggggcaat
gacagatcggcagaagcctgatgcagagcatccgagcggggccgggcaactgatcaaaaaccgctcatccgtcaatatcaaaacttttgat
acagctattgccccaccctgcaagccacgactagactgcgcgacctatgagcctgcgcctgcccgaatccgccacgacgactgcgacc
agctggccgcccgtgcaaggccggcgcgga

SEQ ID NO: 46 Pwp2
ACGGTTTGACACAGTAATTA AAAAGACGTATAATTGCGTTGTGTAAGGCTAACTATC
GTTCAAAATTTAGTTGGTAACAACAA

SEQ ID NO: 47 cobW-Pkt-Psp2-cbtB (5-fold)
Catcgtgaatctcctgcgggggctgcttcgaaactcgaagggaatgaaaaaggccgggtatttgcgccagccggggccccgtggggca
atgacagatcggcagaagcctgatgcagagcatccgagcggggccgggcaactgatcaaaaaccgctcatccgtcaatatcaaaacttttg
atacagctattgccccaccctgcaagccacgactagactgcgcgacctatgagcctgcgcctgcccgaatccgccacgacgactgcgac
cagctggccgcccgtgcaaggccggcgcggaTCTAGCTGCGCATAACGGTTTGACACAGTAATTA
AAGACGTATAATTGCGTTGTGTAAGGCTAACTATCGTTCAAAATTTAGTTGGTAACA
ACAAtg

SEQ ID NO: 48 Pzwf
gatgctgaagcgcgtggcctgctgcgggtcgtgcaggatcacttcggcgaccttcgctcggcctgttcagctgttcagacggctctgga
tctgtccagcaggttttcatccgtgctcctgggcaatcgacgggtggccgggtaggggcccagcggcgctatcctaactcagggcc
ggcaggcgaccaacaacggcgcgaggtggcaaaaatatctgtttaattactacatatgttctaatgccggcgtgtaaggctaactatcgtt
caaaatttagttgtaacaacaa

SEQ ID NO: 49 Pzwf-tonB (3-fold)
gatgctgaagcgcgtggcctgctgcgggtcgtgcaggatcacttcggcgaccttcgctcggcctgttcagctgttcagacggctctgga
tctgtccagcaggttttcatccgtgctcctgggcaatcgacgggtggccgggtaggggcccagcggcgctatcctaactcagggcc
ggcaggcgaccaacaacggcgcgaggtggcaaaaatatctgtttaattactacatatgttctaatgccggcgtgtaaggctaactatcgtt
caaaatttagttgtaacaacaaatg

SEQ ID NO: 50 Psp9

GGGGGTTGACAACTGCGTGTTTGTCTGTTATAATATCCCGGTGTAAGGCTAACTATC
GTTCAAAATTTAGTTGGTAACAACAA

SEQ ID NO: 51 Psp9-tonB (5-fold)

GGGGGTTGACAACTGCGTGTTTGTCTGTTATAATATCCCGGTGTAAGGCTAACTATC
GTTCAAAATTTAGTTGGTAACAACAAatg

Tandem promoters

SEQ ID NO: 65 Pcm-Pc4

CCTCGAATGTGCAAAAACGCAGACCATACTTGCACATCACCGCATTGAGTACATCA
AAAATGCACTGTTAGGATCGATCCAGACAACAAAAAAGCCACAGGCTGGGAGAATC
CCGGCCCCCGCCTACCCGCCCCAGCCACCCCGGACTCAGCAAGGATGCTGGCCCCG
GCCTGGGCGGAGACGTCTTTCGCGCCCGACCATCAGAACAAGAGGACAACCCC

SEQ ID NO: 70 Pc3-Pc1

CGTGGCGACTCTCATTGTTAGAAAACGCACAGCAGGTGACTTTAAACGTTTCGTATTT
TTATCGCGAACGAACGACTAGGCTCCATCGTCATACCCAAAAGAACAAGAACGACG
AGGGACTTTCGGGCGTTTGACATGTGGATGTAATCCTGTTATAATTTTTTAGTGTAAG
GCTAACTATCGTTCAAAATTTAGGTGGTAACAACAAATG

SEQ ID NO: 71 Pc1-Pc3

GGCGTTTGACATGTGGATGTAATCCTGTTATAATTTTTTAGTGTAAGGCTAACTATCG
TTCAAAATTTAGGTGGTAACAACAACGTGGCGACTCTCATTGTTAGAAAACGCACAG
CAGGTGACTTTAAACGTTTCGTATTTTTATCGCGAACGAACGACTAGGCTCCATCGTC
ATACCCAAAAGAACAAGAACGACGAGGGACTTTCCATG

SEQ ID NO: 72 Pc3-Pzwf

CGTGGCGACTCTCATTGTTAGAAAACGCACAGCAGGTGACTTTAAACGTTTCGTATTT
TTATCGCGAACGAACGACTAGGCTCCATCGTCATACCCAAAAGAACAAGAACGACG
AGGGACTTTCGGGCGACCAACAACGGCGCGAGGTGGCAAAAATATCTTGTTTAATT
ACTACATATTTGTCTTAATGCCGGCGTGTAAGGCTAACTATCGTTCAAAATTTAGTTG
GTAACAACAAATG

DhaB expression module

SEQ ID NO: 66

CAGGTCGACTCTAGAGCTGATCCTTTTTGGCAGTTCGTTCCGGCCTCTTCGCGGGCAC
GCCCCGCTCCACAGGGATCGCGTTACCTTGTGGGAGCGGGCGTGCCCCGCGAAGAGG
CCAGCACAGACTTACCCTGTGCTAAAACGCACAGCGGCTGCGCGAAATCTCGTGTT
TCCTCCACGAAATTACTACTAAGATGGATCGGGACAAGAATAATAATCAGGGGAG
AGGTTGCACATGAAAAGATCAAAACGATTTGCAGTACTGGCCAGCGCCCCGTCAA
TCAGGACGGGCTGATTGGCGAGTGGCCTGAAGAGGGGCTGATCGCCATGGACAGCC
CCTTTGACCCGGTCTCTTCAGTAAAAGTGGACAACGGTCTGATCGTCGAGCTGGACG
GCAAACGCCGGGACCAGTTTGACATGATCGACCGATTTATCGCCGATTACGCGATCA
ACGTTGAGCGCACAGAGCAGGCAATGCGCCTGGAGGCGGTGGAAATAGCCCGCATG
CTGGTGGATATTCACGTCAGTCGGGAGGAGATCATTGCCATCACTACCGCCATCACG

CCGGCCAAAGCGGTTCGAGGTGATGGCGCAGATGAACGTGGTGGAGATGATGATGGC
GCTGCAGAAGATGCGTGCCCGCCGACCCCTCCAACCAGTGCCACGTCACCAATCT
CAAAGATAATCCGGTGCAGATTGCTGCTGACGCCGCCGAGGCCGGGATCCGCGGCT
TCTCAGAACAGGAGACCACGGTCGGTATCGCGCGCTATGCGCCGTTTAAACGCCCTGG
CGCTGTTGGTTCGGTTCGCAGTGCGGGCCGCCCGGCGTTTTGACGCAGTGCTCGGTGG
AAGAGGCCACCGAGCTGGAGCTGGGCATGCGTGGCTTAACCAGCTACGCCGAGACG
GTGTCGGTCTACGGCACCGAAGCGGTATTTACCGACGGCGATGATACTCCGTGGTCA
AAGGCGTTCCTCGCCTCGGCCTACGCCTCCCGCGGGTTGAAAATGCGCTACACCTCC
GGCACCGGATCCGAAGCGCTGATGGGCTATTCGGAGAGCAAGTCGATGCTCTACCT
CGAATCGCGCTGCATCTTCATTACCAAAGGCGCCGGGGTTCAGGGGCTGCAAAACG
GCGCGGTGAGCTGTATCGGCATGACCGGCGCTGTGCCGTCGGGCATTTCGGGCGGTG
CTGGCGGAAAACCTGATCGCCTCTATGCTCGACCTCGAAGTGGCGTCCGCCAACGAC
CAGACTTTCTCCCACTCGGATATTCGCCGCACCGCGCGCACCTTGATGCAGATGCTG
CCGGGCACCGACTTTATTTTCTCCGGCTACAGCGCGGTGCCGAACCTACGACAACATG
TTCGCCGGCTCGAACTTCGATGCGGAAGATTTTGATGATTACAACATCCTGCAGCGT
GACCTGATGGTTGACGGCGGCCTGCGTCCGGTGACCGAGGCGGAAACCATTGCCAT
TCGCCAGAAAGCGGCGCGGGCGATCCAGGCGGTTTTCCGCGAGCTGGGGCTGCCGC
CAATCGCCGACGAGGAGGTGGAGGCCGCCACCTACGCGCACGGTAGCAACGAGATG
CCGCCGCGTAACGTGGTGGAGGATCTGAGTGCGGTGGAAGAGATGATGAAGCGCAA
CATCACCGGCCTCGATATTGTCGGCGCGCTGAGCCGCAGCGGCTTTGAGGATATCGC
CAGCAATATTCTCAATATGCTGCGCCAGCGGGTCACCGGCGATTACCTGCAGACCTC
GGCCATTCTCGATCGGCAGTTCGAGGTGGTGAGTGCGGTCAACGACATCAATGACTA
TCAGGGGCGGGCACCGGCTATCGCATCTCTGCCGAACGCTGGGCGGAGATCAAAA
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AGACAACCCAAATTCAGCCCTCTTTTACCCTGAAAACCCGCGAGGGCGGGGTAGCTT
CTGCCGATGAACGCGCCGATGAAGTGGTGATCGGCGTCGGCCCTGCCTTCGATAAA
CACCAGCATCACACTCTGATCGATATGCCCCATGGCGCGATCCTCAAAGAGCTGATT
GCCGGGGTGGAAGAAGAGGGGCTTCAGCCCGGGTGGTGCGCATTCTGCGCACGTC
CGACGTCTCCTTTATGGCCTGGGATGCGGCCAACCTGAGCGGCTCGGGGATCGGCAT
CGGTATCCAGTCGAAGGGGACCACGGTCATCCATCAGCGCGATCTGCTGCCGCTCA
GCAACCTGGAGCTGTTCTCCAGGCGCCGCTGCTGACGCTGGAAACCTACCGGCAG
ATTGGCAAAAACGCCGCGCGCTATGCGCGCAAAGAGTCACCTTCGCCGGTGCCGGT
GGTGAACGATCAGATGGTGCGGCCGAAATTTATGGCCAAAGCCGCGCTATTTTCATAT
CAAAGAGACCAAACATGTGGTGCAGGACGCCGAGCCCGTCACCCTGCACGTGCACT
TAGTTAGGGAGTAAAGATGAGCGAGAAAACCATGCGCGTGCAAGGATTATCCGTTAG
CCACCCGCTGCCCGGAGCATATCCTGACGCCTACCGGCAAACCATTGACCGATATTA
CCCTCGAGAAGGTGCTCTCTGGCGAGGTGGGCCCGCAGGATGTGCGGATCTCCTGCC
AGACCCTTGAGTACCAGGCGCAGATTGCCGAGCAGATGCAGCGCCATGCGGTGGCG
CGCAATTTCCGCCGCGCGGGCGGAGCTTATCGCCATTCCTGACGAGCGCATTCTGGCT
ATCTATAACGCGCTGCGCCCGTTCCGCTCCTCGCAGGCGGAGCTGCTGGCGATCGCC
GACGAGCTGGAGCACACCTGGCATGCGACAGTGAATGCCGCCTTTGTCCGGGAGTC
GGCGGAAGTGTATCAGCAGCGGCATAAGCTGCGTAAAGGAAGCTAAGAGGAGGAC
AGCATGCCGTTAATAGCCGGGATTGATATCGGCAACGCCACCACCGAGGTGGCGCT
GGCGTCCGACGACCCGCAGGCGAGGGCGTTTGTGTCAGCGGGATCGTCGCGACGA
CGGGCATGAAAGGGACGCGGGACAATATCGCCGGGACCCTCGCCGCGCTGGAGCAG
GCCCTGGCGAAAACACCGTGGTCGATGAGCGATGTCTCTCGCATCTATCTTAACGAA

GCCGCGCCGGTGATTGGCGATGTGGCGATGGAGACCATCACCGAGACCATTATCAC
CGAATCGACCATGATCGGTCATAACCCGCAGACGCCGGGCGGGGTGGGCGTTGGCG
TGGGGACGACTATCGCCCTCGGGCGGCTGGCGACGCTGCCGGCGGGCGCAGTATGCC
GAGGGGTGGATCGTACTGATTGACGACGCCGTCGATTTCTTGACGCCGTCGTGGTGG
CTCAATGAGGCGCTCGACCGGGGGATCAACGTGGTGGCGGGCGATCCTCAAAAAGGA
CGACGGCGTGCTGGTGAACAACCGCCTGCGTAAAACCCTGCCGGTGGTAGATGAAG
TGACGCTGCTGGAGCAGGTCCCCGAGGGGGTAATGGCGGGCGGTGGAAGTGGCCGCG
CCGGGCCAGGTGGTGC GGATCCTGTGCAATCCCTACGGGATCGCCACCTTCTTCGGG
CTAAGCCCCGGAAGAGACCCAGGCCATCGTCCCCATCGCCCGCGCCCTGATTGGCAA
CCGTTTCAGCGGTGGTGCTCAAGACCCCGCAGGGGGATGTGCAGTCGCGGGTGATCC
CGGCGGGCAACCTCTACATTAGCGGCGAAAAGCGCCGCGGAGAGGCCGATGTCGCC
GAGGGCGCGGAAGCCATCATGCAGGCGATGAGCGCCTGCGCTCCGGTACGCGACAT
CCGCGGGCAACCGGGCACTCACGCCGGCGGCATGCTTGAGCGGGTGC GCAAGGTAA
TGGCGTCCCTGACCGACCATGAGATGAGCGCGATATACATCCAGGATCTGCTGGCG
GTGGATACGTTTATTCCGCGCAAggtgcagggcGGGATGGCCGGCGAGTGCGCCATGGAA
AATGCCGTCGGGATGGCGGCGATGGTGAAAGCGGATCGTCTGCAAATGCAGGTTAT
CGCCCGCGAACTGAGCGCCCGACTGCAGACCGAGGTGGTGGTGGGCGGGCGTGGAGG
CCAACATGGCCATCGCCGGGGCGTTAACCACTCCCGGCTGTGCGGGCGCCGCTGGCG
ATCCTCGACCTCGGCGCCGGCTCGACGGATGCGGCGATCGTCAACGCGGAGGGGCA
GATAACGGCGGTCCATCTCGCCGGGGCGGGGAATATGGTCAGCCTGTTGATTAAAA
CCGAGCTGGGCCTCGAGGATCTTTCGCTGGCGGAAGCGATAAAAAAATACCCGCTG
GCCAAAGTGGAAGCCTGTTTCAGTATTCGTCACGAGAATGGCGCGGTGGAGTTCTTT
CGGGAAGCCCTCAGCCCGGCGGTGTTTCGCCAAAGTGGTGTACATCAAGGAGGGCGA
ACTGGTGCCGATCGATAACGCCAGCCCGCTGGAAAAAATTCGTCTCGTGCCCGGC
AGGCGAAAGAGAAAGTGTTTGTCACCAACTGCCTGCGCGCGCTGCGCCAGGTCTCA
CCCGGCGGTTCCATTCGCGATATCGCCTTTGTGGTGCTGGTGGGCGGGCTCATCGCTG
GACTTTGAGATCCCGCAGCTTATCACGGAAGCCTTGTCGCACTATGGCGTGCTGCC
GGGCAGGGCAATATTCGGGGAACAGAAGGGCCGCGCAATGCGGTGCGCCACCGGGCT
GCTACTGGCCGGTCAGGCGAATTAACCTCTCAAGGAGGGGTGTGTTATGTCGCTTTCA
CCGCCAGGCGTACGCCTGTTTTACGATCCGCGCGGGCACCATGCCGGCGCCATCAAT
GAGCTGTGCTGGGGGCTGGAGGAGCAGGGGGTCCCCTGCCAGACCATAACCTATGA
CGGAGGCGGTGACGCCGCTGCGCTGGGCGCCCTGGCGGCCAGAAGCTCGCCCTGC
GGGTGGGTATTGGGCTCAGCGCGTCCGGCGAGATAGCCCTCACTCATGCCCAGCTGC
CGGCGGACGCGCCGCTGGCTACCGGACACGTCACCGATAGCGACGATCATCTGCGT
ACGCTCGGCGCCAACGCCGGGCAGCTGGTTAAAGTCCTGCCGTTAAGTGAGAGAAA
CTGACGGTGATCCCGTCCTCTCACGCTTTTGACGTGAAACTCCGCTCCCGGCCGCCG
AGGTGTCGGGCGGTTCGCCAGCAAGGACTGGGCGTCCCCCTCGGTCTTCAAGGAG
CAACACCGAAACGCTATCGCGCGGTGTGAAAGCCGTGGCAGTAGAGGCTGAAACAA
CAATAAAAGCCCCAGCAGGGGCAGGAGAGCCCGCAATGTCTGATCCAGCAGTGACG
AGTGCGACACAGAGCAGGACCTACGAGCGGCAG

kgsA expression module

SEQ ID NO: 67 kgsA expression module

CAAGGTGCCCAGCGCCCCCTCCAGCGAGGTGATGCGCCGCGACACAGTGGTGTAGT
CCACGCTCAGGCGCTTGGCGGCGCTGCTGGCCTTGCGCGTACGCGCCACTTCAAGGA
AGAACTTCAGGTCGTCCAGTTGAGCGCGCTCAGGGATGTAAGGTCTTTTTGCATGA

TGATCCGGTTTTTTTTGTGCGTTCTTGTTGGATGTTTGCACATCTATACTCGAAACAAG
CCTCAGGACGCCACCTCGCGTTTGCACGGCGCTGGCGATCTCGTCCCGACAATAATT
CGGAGGGGAACGCAGATGAGAGGATCGGGATCCGCTAACGTGACTTATACGGATAC
GCAACTGCTGATCGACGGTGAGTGGGTCGACGCCGCGAGCGGCAAGACGATCGACG
TCGTGAACCCGGCGACCGGCAAGCCGATCGGCAGGGTGGCCCATGCGGGCATCGCC
GATCTCGACCGTGCGCTCGCCGCCGCGCAAAGCGGCTTCGAGGCATGGCGCAAGGT
GCCCCGCGCACGAGCGCGCGGCGACGATGCGCAAGGCGGCCGCGCTGGTGCGTGAAC
GCGCCGACGCGATCGCGCAGCTGATGACGCAGGAGCAGGGCAAGCCGCTCACCGAA
GCGCGCGTTCGAAGTGCTGTCGTCCGCGGACATCATCGAATGGTTTCGCGGACGAAGG
CCGCCGCGTGTACGGCCGGATCGTGCCGCCGCGCAACCTCGGCGCACAGCAGACGG
TCGTGAAGGAGCCGGTCGGCCCCGGTCGCCGCGTTACGCCGTGGAATTTCCCGGTCA
ACCAGGTCGTGCGCAAGCTGAGCGCCGCGCTGGCAACCGGCTGTTTCGTTCTCGTGA
AAGCGCCGGAAGAAACCCCCGCGTCGCCGGCCGCGCTGCTGCGCGCCTTCGTTCGAC
GCAGGCGTGCCGGCCGGCGTGATCGGCCTCGTGTACGGCGATCCGGCCGAAATCTC
GTCGTACCTGATCCCGCACCCGGTGATCCGCAAGGTCACGTTACGGGTTTCGACGCC
GGTCGGCAAGCAGCTCGCCTCGCTGGCGGGGcctgcacaTGAAGCGCGCGACGATGGAGC
TGGGCGGGCACGCACCGGTGATCGTGGCCGAAGACGCCGACGTTGCGCTCGCGGTG
GCAGCGGCCGCGCGCGCAAGTTCCGCAACGCGGGGCAGGTCTGCATCTCGCCGAC
GCGCTTCCTCGTGCACAACAGCATCCGCGACGAATTCACGCGCGCGCTGGTCAAGC
ATGCCGAAGGGCTGAAGGTCGGCAACGGCCTCGAGGAAGGCACGACGCTCGGCGC
GCTCGCAACCCGCGCCGGCTGACCGCGATGGCGTCGGTCATCGACAACGCGCGCA
AGGTCGGTGCGAGCATCGAAACCGGCGGCGAGCGGATCGGCTCGGAAGGCAACTTC
TTCGCGCCGACCGTGATCGCGAACGTGCCGCTCGATGCGGACGTGTTCAACAACGA
GCCGTTTCGGCCCCGGTCGCGGCGATTTCGCGGTTTCGACAAGCTCGAAGAGGCGATCG
CGGAAGCGAACCGTTTGCCGTTTCGGTCTTGCCGGCTACGCGTTACGCGTTTCGTTTCG
CGAACGTGCACCTGCTCACGCAGCGCCTCGAAGTCGGGATGCTGTGGATCAACCAG
CCGCCGACTACATGGCCGGAATGCCGTTTCGGCGGCGTGAAGGACTCGGGCTACGG
TTCGGAAGGCGGCCCGGAAGCGCTCGAGCCGTACCTCGTCACGAAGTCGGTGACGG
TAATGGCCGTCTGA

UTR gdrAB

SEQ ID NO: 68 UTR gdrA
TAAAGGAAGCTAAGAGGAGGACAGC

SEQ ID NO: 69 UTR gdrB
ATTA ACTCTCAAGGAGGGGTGTGTT

B12 cobG sensors

SEQ ID NO: 73 cobG based B12 sensor
CCAGATGCCGACGATGGTCAGCCAGGGCGTCATGGGGATTCCTCTGAAGGGATGCG
ATGATCGATCCGACGGGCAGGCTTGTTCCGCCCTCGGGCAAAGCAGGCATAATACC
CGCATCGTCGGTGCTCGTAGGACGCTTCGCTGTTTGAAGGCGATGCATCCGAGAGCC
GAAGAGGGAAACACGGAAAAACCGTGGCTGCCCGCAACTGTAAGCAGCGAGTCC
GCGCACTTCGACCACAGCGTCTGTTGTCGTCGATCTGGCCACTGGGCAACCGGGAAG
GCCGTGCCGGATGAGGACCTGCCAGCCAGGAGACCTGCCGACGAAACCAGTCGCGC
GTGCAGACATCGAGCGGGGTGTATCGGTGTCGTGAAGTCCCCTGTGGGGATTTCGCA

GGTCACCGCGACCCAGCCCTGGTGACCTCAATGCAGAGCAAAGGCGAAGAACTGTT
TACCGGCGTGGTGCCGATTCTGGTGGAAGCTGGATGGCGATGTGAACGGCCATAAATT
TAGCGTGCCTGGCGAAGGCGAAGGCGATGCGACCAACGGCAAAGCTGACCCTGAAAT
TTATTTGCACCAACCGGTAAACTGCCGGTGCCGTGGCCGACCCTGGTGACCACCTGG
GTTATGGTGTGCAGTGCTTTGCACGTTATCCGGATCACATGAAACGTCATGATTTCTT
TAAAAGCGCGATGCCGGAAGGCTATGTGCAGGAACGTACCATTAGCTTTAAAGATG
ATGGCACCTATAAAACCCGTGCGGAAGTGAAATTTGAAGGCGATACCCTGGTGAAC
CGTATTGAACTGAAAGGCATTGATTTTAAAGAAGATGGCAACATTCTGGGGCCATAA
ACTGGAATATAACTTTAACAGCCATAAAGTGTATATTACCGCGGATAAACAGAAAA
ACGGCATTAAAGCGAACTTTAAAATTCGTCATAACGTGGAAGATGGCAGCGTGCAG
CTGGCGGATCATTATCAGCAGAACACCCCGATTGGCGATGGCCCGGTGCTGCTGCCG
GATAACCATTATCTGAGCACCCAGAGCGTGCTGCTGAAAGATCCGAACGAAAAACG
TGATCACATGGTGCTGCTGGAATTTGTGACCGCGGCGGCATGGATGAACTGTATAAA
CACCATCACCATCACCATTAA

SEQ ID NO: 74 cobG' based B12 sensor

CCAGATGCCGACGATGGTCAGCCAGGGCGTCATGGGGATTCTCTGAAGGGATGCG
ATGATCGATCCGACGGGCAGGCTTGTTCCGCCCTCGGGCAAAGCAGGCATAATACC
CGCATCGTCGGTGCTCGTAGGACGCTTCGCTGTTTGAAGGCGATGCATCCGAGAGCC
GAAGAGGGAAACACGGA AAAACCGTGCTGCCCCCGCAACTGTAAGCAGCGAGTCC
GCGCACTTCGACCACAGCGTCTGTTGTCGTCGATCTGGCCACTGGGCAACCGGGAAG
GCCGTGCCGGATGAGGACCTGCCAGCCAGGAGACCTGCCGACGAAACCAGTCGCGC
GTGCAGACATCGAGCGGGGTGTATCGGTGTCGTGAAGTCCCCTGTGGGGATTTCGA
GGTCACCGCGACCCAGCCCTGGTGACCTCAATGCAAGACTCCTCAGCTCTGCCCGTC
CGTCCGCATGCCTGCCCTGGCCTGCTGCGCATCCAGAGCAAAGGCGAAGAACTGTTT
ACCGGCGTGGTGCCGATTCTGGTGGAAGCTGGATGGCGATGTGAACGGCCATAAATT
AGCGTGCGTGGCGAAGGCGAAGGCGATGCGACCAACGGCAAAGCTGACCCTGAAATT
TATTTGCACCAACCGGTAAACTGCCGGTGCCGTGGCCGACCCTGGTGACCACCTGGG
TTATGGTGTGCAGTGCTTTGCACGTTATCCGGATCACATGAAACGTCATGATTTCTTT
AAAAGCGCGATGCCGGAAGGCTATGTGCAGGAACGTACCATTAGCTTTAAAGATGA
TGGCACCTATAAAACCCGTGCGGAAGTGAAATTTGAAGGCGATACCCTGGTGAACC
GTATTGAACTGAAAGGCATTGATTTTAAAGAAGATGGCAACATTCTGGGGCCATAAA
CTGGAATATAACTTTAACAGCCATAAAGTGTATATTACCGCGGATAAACAGAAAA
CGGCATTAAAGCGAACTTTAAAATTCGTCATAACGTGGAAGATGGCAGCGTGCAGC
TGGCGGATCATTATCAGCAGAACACCCCGATTGGCGATGGCCCGGTGCTGCTGCCG
GATAACCATTATCTGAGCACCCAGAGCGTGCTGCTGAAAGATCCGAACGAAAAACG
TGATCACATGGTGCTGCTGGAATTTGTGACCGCGGCGGCATTACCCACGGCATGGA
TGAAGTGTATAAACACCATCACCATCACCATTAA

B12 riboswitch sequences

SEQ ID NO: 75 RS1

Ccagatgccgacgatgggtcagccagggcgctcatggggattcctctgaagggatgcgatgatccgacgggcaggcgtgttcgccct
cgggcaaagcaggcataatacccgcatcggtgctcgttaggacgcttcgctgtttgaaggcgatgcacccgagagccgaagaggga
cacggaaaaaccgtggctgccccgcaactgaagcagcgagtccgcgacttcgaccacagcgtctgtgtcgtcgatctggccactgg

gcaaccgggaaggccgtgccggatgaggacctgccagccaggagacctgccgacgaaaccagtgcgcgtgcagacatcgagcggg
gtgtatcggtgtcgtgaagtcccctgtggggattcgaggtcaccgcgaccagccctgtgacctca

SEq ID NO: 76 RS2

Ggcggatgaaggcgcgcgcgcggttcgccgcgaacgaaggtgccaccggatcaccccgcccgttctgttgataacgaacc
ggttccggatctcgcgagctagagccaggcaaggcggaggatcgtcggggacgcggagttagctgtatcaatgagcagtcacgacg
atccgccaacgcagcatggccgacgcgcgagcagatcgaaaaccagtcacgaggcaggtctcctggctcacagcccttgatcgtccttcg
ccttcccgccgtagtcggcagtggtgtgaaagaacaggctgttcacagtgcgggggagccgtggcgcatccgaagatttcacgttc
cctttagctccggccagtgcgggagaacctcgaaggagggaaggctacgcagcgtggccggggcggtcaatcgccgggatcgggc
gacgcgcagttgacgtgcgggactgccgtgtcagctagcgcgggttcagggtgtctcgcgcgacgcgcgcgaggtgaaacgggaag
ccggtgctccgcaaggaccagtcggcgctgccccgcgaacggtaagcgcatcgagggtcgtcagtagccactgtgccaaaggcatgg
gaaggctggcccatccggcgagagtctctcgtgctgcgaagccggagaccggcctggaatcctcacatttggcaaaccgcggt
gggcgggcgcagggccgtggcgcgaccgatccggcgcggttcgaatgcgttcaacctctgcgttctcactctttcagaggggaacgttcagt
ccagcagcatcctgacgcaacaggcg

DhaB1 SEQ ID NO: 77

MKRSKRFAVLAQRPVNQDGLIGEWPEEGLIAMDSPFDPVSSVKVDNGLIVELDGKRRD
QFDMIDRFIADYAINVERTEQAMRLEAVEIARMLVDIHVSREEIIAITTAITPAKAVEVMA
QMNVVEMMMALQKMRARRTPSNQCHVTNLKDNPVQIAADAAEAGIRGFSEQETTNGI
ARYAPFNALALLVGSQCGRPGVLTQCSVEEATELELGMRLTSYAETVSVYGTEAVFT
DGDDTPWSKAFLASAYASRGLKMRYTSGTGSEALMGYSESKSMYLESRCIFITKGAG
VQGLQNGAVSCIGMTGAVPSGIRAVLAENLIASMLDLEVASANDQTFSHSDIRRTARTL
MQMLPGTDFIFSGYSAPVNYDNMFAGSNFDAEDFDDYNILQRDLMDVGGRLPVTEAET
IAIRQKAARAIQAVFRELGLPPIADEEEVEAATYAHGSNEMPPRNVVEDLSAVEEMMKRN
ITGLDIVGALSRSFGEDIASNILNMLRQRVTGDYLTQSAILDRQFEVVS AVNDINDYQGP
GTGYRISAERWAEIKNIPGVVQPDITIE

DhaB2 SEQ ID NO: 78

MQQTQIQPSFTLKTREGGVASADERADEVVIGVGPAFDKHQHHTLIDMPHGAILKELIA
GVEEGLHARVVRLRTSDVSFMAWDAANLSGSGIGIGIQSKGTTVIHQRDLLPLSNLEL
FSQAPLLTLETYRQIGKNAARYARKESPSPVPVNDQMVRPKFMAKAALFHIKETKHV
VQDAEPVTLHVDLVRE

DhaB3 SEQ ID NO: 79

MSEKTMRVQDYPLATRCPEHILTPTGKPLTDITLEKVLSGEVGPQDVRISCQTLEYQAQI
AEQMQRHAVARNFRRAAELIAPDERILAIYNALRPFRSSQAELLAIADELEHTWHATVN
AAFVRESAEVYQQRHKLKRGKGS

GdrA SEQ ID NO: 80

MPLIAGIDIGNATTEVALASDDPQARAFVASGIVATTGMKGTRDNIAGTLAALEQALAK
TPWSMSDVSRIYLNEAAPVIGDVAMETITETITESTMIGHNPQTPGGVGVGVTIALGR
LATLPAAQYAEGWIVLIDDAVDFLDAVWWLNEALDRGINVVAAILKKDDGVLVNNRL
RKTLPVVDEVTLLEQVPEGVMAAVEVAAPGQVVRLSNPYGIATFFGLSPEETQAIVP
RALIGNRS AVVLKTPQGDVQSRVIPAGNLYISGEKRRGEADV AEGAEAIMQAMSACAP
VRDIRGEPGTHAGGMLERVRKVMASLTDHEMSAIYIQDLLAVDTFIPRKVQGGMAGEC

AMENAVGMAAMVKADRLQMQUIARELSARLQTEVVVGGVEANMAIAGALTTPGCAA
PLAILDLGAGSTDAAIVNAEGQITAVHLAGAGNMVSLLIKTELGLEDSLAEAIKKYPLA
KVESLFSIRHENGAVEFFREALSPAVFAKVVIKEGELVPIDNASPLEKIRLVRRQAKEKV
FVTNCLRALRQVSPGGSIRDIAFVVLVGGSSLDIFEIPLITEALSHYGVVAGQGNIRGTEG
PRNAVATGLLLAGQAN

GdrB SEQ ID NO: 81

MSLSPPGVRLFYDPRGHHAGAINELCWGLEEQGVPCQTITYDGGGDAAALGALAARSS
PLRVGIGLSASGEIALTHAQLPADAPLATGHVTDSDHLRTLGANAGQLVKVLPLSERN

KgsA SEQ ID NO: 82

MANVTYTDQTLLIDGEWVDAASGKTIDVVNPATGKPIGRVAHAGIADLDRALAAQSG
FEAWRKVPAHERAATMRKAAALVRERADAIAQLMTQEQQKPLTEARVEVLSAADIIIEW
FADEGRRVYGRIVPPRNLGAQQTVVKEPVGPAFTAFTPNFPVNQVVRKLSAALATGCS
FLVKAPEETPASPAALLRAFDAGVPAGVIGLVYGDPAEISSYLIPHPVIRKVTFTGSTPV
GKQLASLAGLHMKRATMELGGHAPVIVAEDADVAVKAAGGAKFRNAGQVCISPTR
FLVHNSIRDEFTRALVKHAEGLVGNGLLEGTTLGALANPRRLTAMASVIDNARKVGA
SIETGGERIGSEGNFFAPTIVIANVPLDADVFNNEPFGPVAAIRGFDKLEEAI AEANRLPFG
LAGYAFTRSFANVHLLTQRLEVGMWINQPATPWPEMPFGGVKDSGYGSEGGPEALEP
YLVTKSVTVMVAV

Diol dehydratase

PduC SEQ ID NO: 83

ATGAGATCGAAAAGATTTGAAGCACTGGCGAAACGCCCTGTGAATCAGGATGGTTT
CGTTAAGGAGTGGATTGAAGAGGGCTTTATCGCGATGGAAAGCCCTAACGATCCCA
AACCTTCTATCCGCATCGTCAACGGCGCGGTGACCGAACTCGACGATAAACCGGTTG
AGCAGTTCGACCTGATTGACCACTTTATCGCGCGCTACGGCATTATCTCGCCCGGG
CCGAAGAAGTGATGGCCATGGATTGCGTTAAGCTCGCCAACATGCTCTGCGACCCG
AACGTAAACGCAGCGACATCGTGCCGCTCACTACCGCGATGACCCCGGCGAAAAT
CGTGGAAGTGGTGTTCGCATATGAACGTGGTCGAGATGATGATGGCGATGCAAAAAA
TGCGCGCCCGCCGCACGCCGTCCAGCAGGCGCATGTCACTAATATCAAAGATAAT
CCGGTACAGATTGCCGCCGACGCCGCTGAAGGCGCATGGCGCGGCTTTGACGAGCA
GGAGACCACCGTCGCCGTGGCGCGCTACGCGCCGTTCAACGCCATCGCCCTGCTGGT
CGGTTACAGGTTGGCCGCCCCGGCGTCTCACCCAGTGTTGCTGGAAGAAGCCAC
CGAGCTGAAACTGGGCATGCTGGGCCACACCTGCTATGCCGAAACCATTTCGGTATA
CGGTACGGAACCGGTGTTTACCGATGGCGATGACACCCCGTGGTCGAAAGGCTTCCT
CGCCTCCTCCTACGCCTCGCGCGGCCTGAAAATGCGCTTTACCTCCGGTTCCGGCTC
GGAGGTGCAGATGGGCTATGCCGAAGGCAAATCGATGCTTTATCTCGAAGCGCGCT
GCATCTACATCACCAAAGCCGCCGGGGTGCAAGGCCTGCAGAATGGCTCCGTCAGC
TGTATCGGCGTGCCGTCCGCCGTGCCGTCCGGGATCCGCGCCGTACTGGCGGAAAAC
CTGATCTGCTCAGCGCTGGATCTGGAGTGCGCCTCCAGCAACGATCAAACCTTTACC
CACTCGGATATGCGGCGTACCGCGCGTCTGCTGATGCAGTTCCTGCCAGGTACCGAC
TTTATCTCCTCCGGTTACTCGGCGGTGCCGAACTACGACAACATGTTCCGCCGGTTCC
AACGAAGATGCCGAAGACTTCGATGACTACAACGTGATCCAGCGCGACCTGAAGGT
CGATGGCGGCCTGCGGCCGGTGCGTGAAGAGGACGTGATCGCCATTCGCAACAAAG
CCGCCCGCGCGCTGCAGGCGGTATTTGCCGGCATGGGTTTGCCGCCTATTACGGATG

AAGAAGTAGAAGCCGCCACCTACGCCCACGGTTCAAAAGATATGCCTGAGCGCAAT
ATCGTCGAGGACATCAAGTTTGCTCAGGAGATCATCAACAAGAACCGCAACGGCCT
GGAGGTGGTGAAAGCCCTGGCGAAAGGCGGCTTCCCCGATGTCGCCCAGGACATGC
TCAATATTCAGAAAGCCAAGCTCACCGGCGACTACCTGCATACCTCCGCCATCATTG
TTGGCGAGGGCCAGGTGCTCTCGGCCGTGAATGACGTGAACGATTATGCCGGTCCG
GCAACAGGCTACCGCCTGCAAGGCGAGCGCTGGGAAGAGATTAAAAATATCCCGGG
CGCGCTCGATCCCAATGAACTTGGCTAA

PduD SEQ ID NO: 84

ATGGAAATTAACGAAACGCTGCTGCGCCAGATTATCGAAGAGGTGCTGTCGGAGAT
GAAATCAGGCGCAGATAAGCCGGTCTCCTTTAGCGCGCCTGCGGCTTCTGTCGCCTC
TGCCGCGCCGGTCGCCGTTGCGCCTGTGTCCGGCGACAGCTTCCTGACGGAAATCGG
CGAAGCCAAACCCGGCACGCAGCAGGATGAAGTCATTATTGCCGTCCGGGCCAGCGT
TTGGTCTGGCGCAAACCGCCAATATCGTCGGCATTCCGCATAAAAATATTCTGCGCG
AAGTGATCGCCGGCATTGAGGAAGAAGGCATCAAAGCCCAGGTGATCCGCTGCTTT
AAGTCTTCTGACGTCGCCTTCGTGGCAGTGGAAGGCAACCGCCTGAGCGGCTCCGGC
ATCTCGATCGGTATTCAGTCGAAAGGCCACCAACCGTCATCCACCAGCGCGGCCTGCCG
CCGCTTTCCAATCTGGAACCTTCCCGCAGGCGCCGCTGCTGACGCTGGAAACCTAC
CGTCAGATTGGCAAAAACGCCGCGCGCTACGCCAAACGCGAGTCGCCGCAGCCGGT
GCCGACGCTTAACGATCAGATGGCTCGTCCCAAATACCAGGCGAAGTCGGCCATTTT
GCACATTAAAGAGACCAAATACGTGGTGACGGGCAAAAACCCGCAGGAACTGCGC
GTGGCGCTTTAA

PduE SEQ ID NO: 85

ATGAATACCGACGCAATTGAATCCATGGTACGCGACGTGCTGAGCCGGATGAACAG
CCTACAGGACGGGATAACGCCCGCGCCAGCCGCGCCGACAAACGACACCGTTTCGCC
AGCCAAAAGTTAGCGACTACCCGTTAGCGACCCGCCATCCGGAGTGGGTCAAAACC
GCTACCAATAAAAACGCTCGATGACCTGACGCTGGAGAACGTATTAAGCGATCGCGT
TACGGCGCAGGACATGCGCATCACTCCGGAAACGCTGCGTATGCAGGCGGGCGATCG
CCCAGGATGCCGGACGCGATCGGCTGGCGATGAACTTTGAGCGGGCCGCAGAGCTC
ACCGCGGTTCCCGACGACCGAATCCTTGAGATCTACAACGCCCTGCGCCCATACCGT
TCCACCCAGGCGGAGCTACTGGCGATCGCTGATGACCTCGAGCATCGCTACCAGGC
ACGACTCTGTGCCGCCTTTGTTTCGGGAAGCGGCCGGGCTGTACATCGAGCGTAAGAA
GCTGAAAGGCGACGATTAA

PduG SEQ ID NO: 86

ATGCGCTATATCGCTGGCATTGATATTGGCAACTCCTCGACAGAAAGTCGCCCTGGCG
ACGGTCGATGACGCAGGTGTGCTGAACATTCGCCACAGCGCGTTGGCTGAAACCAC
GGGTATAAAAGGCACATTACGAAATGTGTTTCGGTATCCAGGAGGGCGCTAACGCAGG
CGGCAAAAGCGGCCGGCATTACGCTCAGCGATATTTTCGCTTATTCGCATTAACGAAG
CCACGCCGGTCATTGGCGATGTGGCGATGGAAACCATCACGGAAACCATCATCACC
GAGTCCACCATGATCGGCCATAACCCGAAGACACCCGGCGGCGTCGGACTGGGGGT
CGGCATCACCATCACACCAGAGGGCGCTGCTGTCTGCTCCGCGGACACTCCCTATAT
TCTGGTGGTCTCCTCGGCCTTTGACTTTGCCGATGTCGCCGCGATGGTCAATGCGGC
AACGGCAGCGGGCTATCAGATAACCGGCATTATTTTGCAGCAGGATGACGGCGTGC
TGGTCAATAACCGGCTACAGCAACCGCTGCCGGTGATCGACGAAGTTCAGCATATC

GACCGGATTCCACTTGGCATGCTGGCGGCCGTCGAGGTCGCTTTACCCGGTAAGATC
ATCGAAACGCTCTCCAACCCCTACGGTATTGCGACCGTTTTTCGATCTCAACGCCGAG
GAGACCAAAAATATCGTGCCAATGGCGCGGGCGCTGATTGGCAACCGCTCGGCCGT
GGTGGTGAAAACCCCTCCGGCGACGTCAAGGCCCGCGCTATTCCGGCAGGTAATC
TGCTGCTCATCGCTCAGGGGCGCAGCGTACAGGTTGATGTGGCCGCCGGGGCGGAA
GCCATCATGAAAGCGGTTGACGGCTGCGGCAAACCTGGACAACGTCGCGGGAGAAGC
GGGCACCAATATCGGCGGCATGCTTGAGCACGTGCGCCAGACCATGGCGGAGCTTA
CCAATAAGCCAGCTCAGGAGATCCGCATTCAGGATCTGCTGGCCGTTGATACGGCG
GTGCCAGTCAGCGTGACCGGCGGTCTTGCGGGGGAGTTCTCGCTGGAGCAGGCGGT
GGGTATCGCCTCGATGGTCAAGTCGGATCGCCTGCAGATGGCCCTCATCGCCCGTGA
AATTGAGCACAACTGCAGATTGCGGTTTCAGGTGGGCGGCGCCGAAGCGGAGGCGG
CCATTCTTGGGGCGCTCACCCTCCCGGCACCACGCGCCCGCTGGCGATCCTCGATC
TGGGCGCCGGGTCGACCGACGCCTCCATTATCAATGCGCAGGGAGAGATCAGCGCC
ACTCACCTGGCCGGCGCCGGCGATATGGTCACGATGATCATCGCCCGCGAGCTGGG
GCTTGAGGACCGCTACCTGGCGGAAGAGATCAAAAATATCCGCTGGCAAAAGTCG
AAAGCCTGTTTCATCTGCGTCATGAAGACGGCAGCGTCCAGTTTTTTCCGTCGGCCTT
ACCACCGGCGGTATTTGCCCGCGTCTGCGTGGTGAAACCGGATGAACTGGTTCCCT
GCCCGGCGATCTGCCGCTGGAGAAAGTGCGCGCCATTCGCCGTAGCGCCAAATCAC
GCGTCTTTGTCTACTAACGCCCTGCGGGCGTTACGCCAGGTGAGCCCTACCGGCAACA
TTCGCGACATCCCGTTTCGTGGTGCTGGTGGGCGGCTCGTCCCTCGATTTTCGAGATCC
CCCAGCTGGTACCGACGCGCTGGCGCACTACCGGCTGGTTGCCGGGCGCGGCAAC
ATCCGCGGCTGTGAAGGCCACGCAATGCGGTGCGCCAGCGGATTACTCCTTTCTTG
CAAAAAGGAGGCACACATGGAGAGTAG

PduH SEQ ID NO: 87

ATGGAGAGTAGCGTAGTCGCCCCCGCCATCGTCATTGCCGTCCTGACGAATGCAGC
GAACAGTGGCGCGATGTCCTGCTGGGCATTGAAGAGGAAGGCATTCCTTTTGTCTG
CAGCCGCAGACCGGCGGCGATCTTATCCATCACGCCTGGCAGGCGGCGCAGCGTTC
GCCGCTGCAGGTAGGCATCGCCTGCGACCGGGAACGGCTCATCGTGCCTACAAAA
ATTTACCCGCATCAACTCCGCTGTTTTTCGCTGATGTATCACCAGAACAGGCTGGCCC
GGCGAAACACTGGCAACAATGCGGCTCGTCTCGTCAAAGGGATCCCATTTCGGGAT
CGCCATGCTTAA

PduC SEQ ID NO: 88

MRSKRFEALAKRPVNQDGFVKEWIEEGFIAMESPNDPKPSIRIVNGAVTELDDKPVEQF
DLIDHFIARYGINLARAEEVMAMDSVKLANMLCDPNVKRSDIVPLTTAMTPAKIVEVVS
HMNVVEMMMAMQKMRARRTPSQQAHVTNIKDNPVQIAADAAEGAWRGFDEQETTV
AVARYAPFNAIALLVGSQVGRPGVLTQCSLEEATELKLGM LGHTCYAETISVYGTEPVF
TDGDDTPWSKGFLASSYASRGLKMRFTSGSGSEVQMGY AEGKSMLYLEARCIYITKAA
GVQGLQNGSVSCIGVPSAVPSGIRAVLAENLICSALDLECASSNDQTFTHSDMRRTARLL
MQFLPGTDFISSGYSAVPNYDNMFAGSNEDAEDFDDYNVIQRDLKVDGGLRPVREEDVI
AIRNKAARALQAVFAGMGLPPITDEEVEAATYAHGSKDMPERNIVEDIKFAQEIINKNRN
GLEVVKALAKGGFPDVAQDMLNIQKAKLTGDYLHTSAIIVGEGQVLSAVNDVNDYAGP
ATGYRLQGERWEEIKNIPGALDPNELG

PduD SEQ ID NO: 89

MEINETLLRQIIEVLSEMKSGADKPVSFSAAPAASVASAAPVAVAPVSGDSFLTEIGEAKP
GTQQDEVIIAVGPAFGLAQTANIVGIPHKNILREVIAGIEEEGIKARVIRCFKSSDVAFVAV
EGNRLSGSGISIGIQSKGTTVIHQRLPPLSNLELFPQAPLLTLETYRQIGKNAARYAKRES
PQPVPTLNDQMARPKYQAKSAILHIKETKYVVTGKNPQELRVAL

PduE SEQ ID NO: 90

MNTDAIESMVRDVL SRMNSLQDGITPAPAAPTNDTVRQPKVSDYPLATRHPEWVK TAT
NKTLDDL TLE NVLSDRVTAQDMRITPETLRMQAAIAQDAGRDR LAMNFERAAELTAVP
DDRILEIYNALRPYRSTQAELLA IADDLEHRYQARLCAAFVREAAGLYIERKKLKGDD

PduG SEQ ID NO: 91

MRYIAGIDIGNSSTEVALATVDDAGVLNIRHSALAETTGIKGTLRNVFGIQEALTQAAKA
AGIQLSDISLIRINEATPVIGDVAMETITETIITESTMIGHNPKTPGGVGLGVGITITPEALLS
CSADTPYILVVSSAFDFADVAAMVNAATAAGYQITGIILQQDDGVLVNNRLQQPLPVID
EVQHIDRIPLGMLAAVEVALPGKIIETLSNPYGIATVFDLNAEETKNIVPMARALIGNRSA
VVVKTPSGDVKARAIPAGNLLLIAQGRSVQVDVAAGAEAIMKAVDGCGKLDNVAGEA
GTNIGGMLEHVRQTMAELTNKPAQEIRIQDLLAVDTAVPVSVTGGLAGEFSLEQAVGIA
SMVKSDRLQMALIAREIEHKLQIAVQVGGAEEAAILGALTTPGTTRPLAILDLGAGSTD
ASIINAQGEISATHLAGAGDMVTMIARELGLEDRYLAEEIKKYPLAKVESLFHLRHEDG
SVQFFPSALPPAVFARVCVVKPDELVPLPGDLPLEKVRAIRRS AKSRVFVTNALRALRQV
SPTGNIRDIPFVVLVGGSSLD FEIPQLVTDALAHYRLVAGRGNIRGCEGPRNAVASGLLL
SWQKGGTHGE

PduH SEQ ID NO: 92

MESSVVAPAIVIAVTDECSEQWRDVLLGIEEEGIPFVLQPQTGGDLIHHAWQAAQRSPLQ
VGIACDRERLIVHYKNLPASTPLFSLMYHQNRLARRNTGNNAARLVKGIPFRDRHA