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(54) Title: CODON OPTIMIZED PMCV SEQUENCES

(57) Abstract: The present disclosure provides exemplary codon optimized nucleic acid sequences encoding Piscine Myocarditis Virus (PMCV). Expression vectors comprising one or more of the described codon optimized nucleic acids sequences are also provided.



CODON OPTIMIZED PMCV SEQUENCES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional
5 Application Serial No. 63/523,476, filed on June 27, 2023, the entire disclosure of which is
incorporated herein by reference.

TECHNICAL FIELD

The disclosure relates to sequences of Piscine Myocarditis Virus (PMCV)
sequences that have been modified to comprise codons optimized for expression in cells.

10 BACKGROUND AND SUMMARY OF THE INVENTION

Cardiomyopathy syndrome (CMS) is an emerging disease of economic
importance in salmon. In particular, the Piscine Myocarditis Virus (PMCV) has been identified
as a causative link for CMS. PMCV is of large economic concern in the salmonid industry
because it causes morbidity and mortality in adult fish that are nearly full grown and almost
15 ready for harvest.

PMCV encodes at least three major proteins: a capsid (ORF1), an RNA-
dependent RNA polymerase (ORF2), and a structural protein of unknown function (ORF3) that
may be involved in virus assembly or egress. However, attempts to propagate PMCV using in
vitro cell culture systems have failed. As a result, traditional live, attenuated, and inactivated
20 vaccine approaches have not yet materialized. Thus, there exists a need for a PMCV vaccine
that utilizes DNA, RNA, or recombinant approaches for design, in particular those utilizing
nucleic acid sequences that have been modified to comprise codons optimized for improved
expression.

Accordingly, the present disclosure, in one aspect, provides nucleic acid
25 molecules (e.g., described in one aspect as sequences) encoding Piscine Myocarditis Virus
(PMCV) protein(s). In one example, the nucleic acid sequences of the present disclosure have
been modified to comprise codons optimized for improved expression in cells.

DETAILED DESCRIPTION

30 Various embodiments are described herein as follows.

Illustrative aspects of the present disclosure include SEQ ID NO: 1. As
described herein, SEQ ID NO: 1 corresponds to a codon optimized sequence for ORF_1 of
PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ ID NO:

1 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 1 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 1 is provided.

Illustrative aspects of the present disclosure include SEQ ID NO: 2. As described herein, SEQ ID NO: 2 corresponds to a codon optimized sequence for ORF_3 of PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 2 is

provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 2 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 2 is provided.

Illustrative aspects of the present disclosure include SEQ ID NO: 3. As described herein, SEQ ID NO: 3 corresponds to a codon optimized sequence for ORF_3 FR13 of PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 3 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 3 is

provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 3 is provided.

Illustrative aspects of the present disclosure include SEQ ID NO: 4. As described herein, SEQ ID NO: 4 corresponds to a second codon optimized sequence for ORF_1 of PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 4 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 4 is provided.

Illustrative aspects of the present disclosure include SEQ ID NO: 5. As described herein, SEQ ID NO: 5 corresponds to a second codon optimized sequence for ORF_3 of PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence

at least 85% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized
5 nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence
10 at least 95% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 5 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 5 is
15 provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 5 is provided.

Illustrative aspects of the present disclosure include SEQ ID NO: 6. As described herein, SEQ ID NO: 6 corresponds to second codon optimized sequence for ORF_3 FR13 of PMCV. In an embodiment, a codon optimized nucleic acid sequence comprising SEQ
20 ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting essentially of SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence consisting of SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence
25 at least 85% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO: 6 is
30 provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized

nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO: 6 is provided. In an embodiment, a codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO: 6 is provided.

In illustrative aspects, an expression vector is provided. The expression vector comprises one or more codon optimized nucleic acids sequences, wherein the one or more codon optimized nucleic acids sequences can comprise any of the codon optimized nucleic acid sequences described herein.

The following numbered embodiments are contemplated and are non-limiting.

1. A codon optimized nucleic acid sequence comprising SEQ ID NO:1.
2. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:1.
3. A codon optimized nucleic acid sequence consisting of SEQ ID NO:1.
4. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:1.
5. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:1.
6. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:1.
7. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:1.
8. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:1.
9. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:1.
10. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:1.
11. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:1.
12. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:1.
13. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:1.

14. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:1.
15. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:1.
- 5 16. A codon optimized nucleic acid sequence comprising SEQ ID NO:2.
17. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:2.
18. A codon optimized nucleic acid sequence consisting of SEQ ID NO:2.
19. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:2.
- 10 20. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:2.
21. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:2.
22. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:2.
- 15 23. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:2.
24. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:2.
- 20 25. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:2.
26. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:2.
27. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:2.
- 25 28. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:2.
29. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:2.
- 30 30. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:2.
31. A codon optimized nucleic acid sequence comprising SEQ ID NO:3.
32. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:3.
33. A codon optimized nucleic acid sequence consisting of SEQ ID NO:3.

34. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:3.
35. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:3.
- 5 36. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:3.
37. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:3.
38. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:3.
- 10 39. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:3.
40. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:3.
- 15 41. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:3.
42. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:3.
43. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:3.
- 20 44. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:3.
45. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:3.
- 25 46. A codon optimized nucleic acid sequence comprising SEQ ID NO:4.
47. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:4.
48. A codon optimized nucleic acid sequence consisting of SEQ ID NO:4.
49. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:4.
- 30 50. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:4.
51. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:4.

52. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:4.
53. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:4.
- 5 54. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:4.
55. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:4.
56. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:4.
- 10 57. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:4.
58. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:4.
- 15 59. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:4.
60. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:4.
61. A codon optimized nucleic acid sequence comprising SEQ ID NO:5.
- 20 62. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:5.
63. A codon optimized nucleic acid sequence consisting of SEQ ID NO:5.
64. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:5.
65. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:5.
- 25 66. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:5.
67. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:5.
- 30 68. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:5.
69. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:5.

70. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:5.
71. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:5.
- 5 72. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:5.
73. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:5.
74. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:5.
- 10 75. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:5.
76. A codon optimized nucleic acid sequence comprising SEQ ID NO:6.
77. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:6.
- 15 78. A codon optimized nucleic acid sequence consisting of SEQ ID NO:6.
79. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:6.
80. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:6.
- 20 81. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:6.
82. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:6.
83. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:6.
- 25 84. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:6.
85. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:6.
- 30 86. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:6.
87. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:6.

88. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:6.

89. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:6.

5 90. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:6.

91. An expression vector comprising one or more codon optimized nucleic acids sequences, wherein the one or more codon optimized nucleic acids sequences are selected from any one of clauses 1 to 90 and any combination thereof.

10

EXAMPLE 1

Exemplary Codon Optimized Nucleic Acid Sequences

Exemplary codon optimized nucleic acid sequence were constructed. The nucleic acid sequences as shown in Table 1 can be utilized according to the present disclosure.

15

Table 1.

Code	SEQ ID NO:
PMCV_ORF1_v1	SEQ ID NO: 1
PMCV_ORF3_v1	SEQ ID NO: 2
PMCV_ORF3mut_v1	SEQ ID NO: 3
PMCV_ORF1_v2	SEQ ID NO: 4
PMCV_ORF3_v2	SEQ ID NO: 5
PMCV_ORF3mut_v2	SEQ ID NO: 6

The sequences include the following:

20 ATGGAGCCCAATACCAGCGTGATCGCTACCGAACAACAACAAGCTGCTATGAGAG
AAGTCGAAGCTGAAGCTGCTGCTAGAGATGAGGTCGTCGAAAAAATTGCCTTTGCC
GAGGGAGCCATGATGGTGCAAACCAGAAGACTGCCCAGCGGAAAATCCAGCGTGG
GCGGATTCCTGGGAGAGCTCGCTCAAAATATCAGGGCTATGAACAGATCCCTGCAT
ACCGACACAAATATGCTCACAGAGGGAGCTATGGTCGATAGGGCTAGAGCCAAGG
TGCATAAGATTATCAGAGAGGGAAACCTGGATTCCAGAGTGTTTCAGCAATACCGGC
25 TCCAATACCATGCTGAGCCTCTGGGTGCCTGCTGTGCCAGGCCCTCCCGCTGTGCCC
GAACACTGGGATGTGGCTCCAAGCTGGTTTGTGTGTAGGCCAGGCAAGAAAGGCG

GAATCAAAATTACCCAGTCCGCTAGCATGGCTGCTCTGAATCCCCTGTTCAGGGGA
GCCGATGTTCGGACCTATTGGAACCGCTGTGAGAGCCGACGTGAATGCCTTCTCCAT
GAACGCTGTGCTCGGAGCTCTGAGGGCTGGCGGATTCAATACAGAGCACAGCCTCG
TCAGCTTTGTGGAGCCCCTGATCAGGATTCTGCTGATGGGAGTGCAGACCCAGGAT
5 AGAGGAACAAGCCCTTGGGACTGGGTGGGCGGAATGTCCAGCAGGATCGTGAACC
CTCTGGTGTTTACCACCTCCGGAATTTTTTTCCCGGCGGACCTAACCTGAGAGTCT
GGGGCGCTAATGACACCGTCGCTAGAATCGTGAATGTGGAAGATTATATGAGGGGA
AGCTGCTGGAGAAGGAAGATTTGATGCTGGATGGGGACCAGAGTTTTGGGGCGGA
ACCGGAGATGATGCTGTCGCTGTCGTGCCAATCAGAGCTGTGGAGGCTGGACTGGG
10 AGAGGTGAATGCTGGATGGACCCTGGCTCATATGGAGTATCCCGTGAAAGTGAGG
CTGCTGGATGTGGATGATAGAACCATCGGACCCGGCGGAAGCCTCCCACTGAATGC
TAATAGGGAGTATACCGCTGCTGGAGCTACCCACGTGCCAGGACCTTACGCTAGAG
TGCTCTATGTGGTGGTCGATCAGAATGCCGATAGATGTGTCGGAGTCAGAGTCCAA
GGACAAGGAGCTGTGATCGATGTCGACCCCGCCCTGAACTATGTCATCGGCGGAGC
15 CGACCTGGGAATGCTGCCCCTGATCCAATGGAGCGTGGGACTCGGAGCTGAAGAT
ATGGCTCAAGGATCCATCGCCCAAACCCAAAGATGGGTGAGAATGTACGGCAATG
AAGATGACTGGGAGTCCGCTTGGCACCTGGTCTCCAGCGCCTATACCGTCTATAGC
CCAGCTTTTAGAAGATCCGGAGTGGCTGTGGAAGGCGGATTTTGGGCTCAGCCTGC
TGCTGGAGCTGCTCCCTTCCCCCTGGGCGGACTGGCCGGCTGGGTGAGATATGATA
20 ACCAAGCTAGAGCTGCTCAAGTGGCTCTGTGTAGGGAAAGAGCTGACATGGCTGA
ATGTCCATGGGGCGGATATAGAGAAAGAGGAGTCAGACCCGGAAGCGTCGCTAAT
TGGCAATATGTGAGATTTGACCCAACCGTCGCTGTGGGAGTGGCTGCCCATTTTTG
GTCCGTGGTCAAAGTCATGGTCGCTCCAGTGCCTGATAGGGCTGCTGCCCTCGCCG
ATATGGCCTGGGGCAAAGGAAAAGTCCAGGCTATGGGAGAAGACGTCATTAATGG
25 CCAAATGGGACAGCCCGAAAGCATGATGAGGGGAGTCGCTCTCAATGAAAATCAA
GGACTGGCTGCTGCTACCGTGAGAAGAGTCGTGGGCCTCGAAAATGAAAGCATGC
AGACCACCCATTGGTCCACCACCGAAGTGGCCATGAATGGCTATTATGGAAGAGCT
GGAGCTACCGCTCATCATGCTGCTTTCCCCCTGAGCGAAGGCGGAACCATGAGGAA
GAGAATCCCCGCCATCGAAATGAGAGAAAATGGAGTCGAAGGCGATCTCATGAAT
30 GACGACCTGTACTCCATCGGAACCGCCCGCGGCTATCTCGCTGTGGAAGGAATGGC
TGGAGCTCAAGGCGGAATTTGGGATGTCTGCAATATCAACTCCCAGGACCAGATG
ACGAAGCTAGAGGAGTCATGAATACCGTCGGAGCTATGGGCGGATGGACCAGAGC
TGTCACCCCTGTGGATAACGTCGCTACAATGAGAGATAATGGAGTGGAAAGGCGAG
CCCTGCGGAATCGTCATGAGCCTGCCTACCTCCGGAACAGCTGTCTGTCGACAGACT

GGCCAACTTTGGACTGCCTCCCGCTAGAGCTGAGCTGAGAGAGGGTGCCTTTCGGAG
GATATCAGAGGTCCGTGACCAATACAAATCATAGAGTGAAAGTCTCCGTCAGCGGC
GGAAGGGCTGTGGTGCAGAAGGGAAATAAGGCTGAAATGAACCCCGTGTTCTGTGA
ACAGAACCCCTGGACAGACCACACTGGGACAGCCTACCACCGATAACCACCGGAAT
5 GACCACCGCTGACTTCCTGGACATCTGA (SEQ ID NO: 1)

ATGTCCAATAAAAATGAAAAGCTTCCTGCTCGTCCTGCTGTGCCTGTGTGTGGGCGA
GGGAATCGTGCCCATGTTTAGAAGAGAGTGGTGCCTGTGTACCGCTGGAAACGCTA
GGGTGCCACTGGTCGGAGAAGGAAGAGCTGAAAAAATTGAACTGTTTAACCAATC
10 CGCTACCTGCGGCAAAAAGGAACTGATCATCACCTGGAAAGGAAAAAGATGGTGT
TATGACATCGAATCCAAAAGGGGCAAGATCCTGGTGAAAACCTCAGCGGCGGAG
GCCACCTCGAGAGAGAAGGCAAAGGATATAAACTCGTGAGAAATGGATTTCACCT
GGCCAGCTTTGGCGGCAAGAAAGAAGAGATCCAAGACTCCAGCCATATCGAAAAG
GTGAATGGCAAGGATGCCATCGTGAAAAAGGGACAGCATGTGGAGCACCTGCCCCG
15 GAGGCAATGACCTGATCGTGACCGAAGGAGGCAATCTCTGCGGCAATGTCGGATTT
TTTGACAACACCCAATGTACCTATAATTCCGTGATCAACATCGGAGGCGGATCCGT
GGATAACAGCCAGGAAGCTAAAAATGACAAGAGCAATACCATCGATAACCTGATC
GACATGCTGCCCCTGGTGGTGGGAATCGCTGGCGGATGCCTGATCGTCATCGTGGT
GCTGTATCTGACCATCAAGTATTGCAAGTGTAAGGAGGAGGAGGAGGAGGAGGAGGAG
20 CCCGCTGAGCCAGAAGAGCATGAAATGAGAGACCTGAGAAGAAGACTGGAACCTA
GGCCTCCCTATCAGAGGGCAAATGGGCGTGGAATTCGAGATCAACGAGGGCCCTGGA
GTTTATGGGAGTGGAGGGATCCGAGAGCCCTGATTCCGGATGTCAAAGCGACGAG
GAAGGCTTTAGGGTGGGAGTGTGA (SEQ ID NO: 2)

25
ATGTCCAATAAAAATGAAAAGCTTCCTGCTCGTCCTGCTGTGCCTGTGTGTGGGCGA
GGGAATCGTGCCCATGTTTAGAAGAGAGTGGTGCCTGTGTACCGCTGGAAACGCTA
GGGTGCCACTGGTCGGAGAAGGAAGAGCTGAAAAAATTGAACTGTTTAACCAATC
CGCTACCTGCCGGAAGGAAAGGAACTGATCATCACCTGGAAAGGAAAAAGATGGTGT
30 TATGACATCGGATCCAAAAGGGGCAAGGTGCTGGTGCAGACCCCTCAGCGGCGGAG
GCCACCTCGAGCAGGAAGGCAAAGGATATAAACTCGTGAGAAATGGATTTCACCT
GGCCAGCTTTGGCGGCAAGAAAGAAGAGATCCAAGACTCCAGCCATATCGAAAAG
GTGAATGGCAAGGATGCCATCGTGAAAAAGGGACAGCATGTGGAGCACCTGCCCCG
GAGGCAATGACCTGATCGTGACCGAAGGAGGCAATCTCTGCGGCAATGTCGGATTT

TTTGACAACACCCAATGTACCTATAATTCCGTGATCAACATCGGAGGCGGATCCGT
GGATAACAGCCAGGAAGCTAAAAATGACAAGAGCAATACCATCGATAACCTGATC
GACATGCTGCCCCCTGGTGGTGGGAATCGCTGGCGGATGCCTGATCGTCATCGTGAT
CCTGTATCTGACCATCAAGTATTGCAAGTGTAAAAAAGAAACAAATCCTGAGC
5 CCGTGGAGCCAGAAGAGCATGAAATGAGAGACCTGAGAAGAAGACTGGAACCTAG
GCCTCCCTATCAGAGGCAAATGGGCGTGGAATTCGAGATCAACGAGGCCCTGGAG
TTTATGGGAGTGGAGGGATCCGAGAGCCCTGATTCCGGATGTCAAAGCGACGAGG
AAGGCTTTAGGGTGGGAGTGTGA (SEQ ID NO: 3)

10 ATGGAGCCTAATACTAGCGTTATAGCTACAGAACAAACAAGCAGCTATGCGCG
AAGTCGAAGCTGAAGCTGCTGCTCGCGATGAGGTCGTCGAAAAATTGCTTTTGCA
GAGGGGGCTATGATGGTCCAAACAAGAAGACTCCCTAGCGGGAAAAGCAGCGTCG
GGGGATTCTTGGGAGAGCTCGCTCAAAATATTAGAGCTATGAACAGAAGCCTCCAT
ACTGACACAAATATGCTCACAGAGGGAGCTATGGTTCGATCGCGCTAGAGCTAAGG
15 TCCATAAGATTATAAGAGAGGGAAACCTCGATAGCAGAGTCTTCAGCAATACAGG
ATCTAATACAATGCTCAGCCTCTGGGTCCCTGCTGTCCCTGGGCCTCCTGCTGTCCC
TGAACACTGGGATGTCGCTCCTAGCTGGTTTGTCTGTCGCCCTGGAAAGAAAGGAG
GAATTAATAATTACTCAGTCTGCTAGCATGGCTGCTCTCAATCCTCTCTTCCGCGGAG
CTGATGTCGGACCTATTGGAAGTCTGTTAGAGCTGACGTCAATGCTTTCAGCATG
20 AACGCTGTCCTCGGGGCTCTCCGCGCTGGAGGGTTCAATACAGAGCACAGCCTCGT
CAGCTTTGTCGAGCCTCTCATAAGAATTCTCCTCATGGGAGTCCAGACTCAGGATA
GAGGAACATCTCCTTGGGACTGGGTTCGGGGGAATGAGCAGCAGAATTGTTAACCT
CTCGTCTTTACTACTTCTGGAAATTTTTTTCCTGGAGGGCCTAACCTCAGAGTCTGG
GGGGCTAATGACACTGTCGCTAGAATTGTCAATGTCGAAGATTATATGAGAGAAGC
25 TGCTGGAGAAGGAAGATTTGATGCAGGGTGGGGGCCTGAGTTTTGGGGAGGAACT
GGAGATGATGCTGTCGCTGTCGTCCCTATTAGAGCTGTCGAGGCTGGACTCGGGGA
GGTCAATGCTGGATGGACTCTCGCTCATATGGAGTATCCTGTAAAGTCCGCCTCCT
CGATGTTGATGATAGAACTATAGGGCCTGGAGGATCTCTCCCTCTCAATGCTAATC
GCGAGTATACAGCTGCTGGGGCAACACACGTCCCTGGACCTTACGCTAGAGTCCTC
30 TATGTTGTTGTCGATCAGAATGCTGATAGATGCGTCGGAGTCCGCGTCCAAGGGCA
AGGAGCAGTCATAGATGTCGACCCTGCTCTCAACTATGTCATTGGAGGGGCTGACC
TCGGAATGCTCCCTCTCATTCAATGGAGCGTCGGACTCGGAGCTGAAGATATGGCT
CAAGGGAGCATAGCTCAAACACAAAGATGGGTCAGAATGTACGGGAATGAAGATG
ACTGGGAGAGCGCTTGGCACCTCGTCAGCTCTGCTTATACTGTCTATTCTCCTGCTT

TTAGACGCAGCGGAGTTGCTGTCTGAAGGGGGGTTTTGGGCTCAGCCTGCAGCTGGA
GCTGCTCCTTTCCCTCTCGGGGGGCTCGCTGGATGGGTCAGATATGATAACCAAGC
TAGAGCTGCTCAAGTCGCTCTCTGTCTCGGAAAGAGCTGACATGGCTGAATGCCCAT
GGGGAGGATATAGAGAACGCGGAGTCCGCCCTGGAAGCGTCGCTAATTGGCAATA
5 TGTCAGATTTGACCCTACTGTCTCGAGTCGGGGTCTGCAGCACATTTTTGGAGCGTCGT
CAAAGTCATGGTCTGCACCTGTTCTGATCTCGCTGCAGCACTCGCTGATATGGCTT
GGGGAAAAGGAAAAGTCCAGGCTATGGGAGAAGACGTCATTAATGGACAAATGGG
GCAGCCAGAAAGCATGATGCGCGGAGTCGCTCTCAATGAAAATCAAGGGCTCGCT
GCTGCAACTGTTAGAAGAGTCGTCGGACTCGAAAATGAAAGCATGCAGACTACAC
10 ATTGAGCACTACAGAAGTCGCTATGAATGGATATTATGGACGCGCTGGGGCTACT
GCTCATCATGCAGCTTTCCCTCTCAGCGAAGGAGGAACTATGAGAAAGAGAATTCC
TGCAATTGAAATGAGAGAAAATGGAGTCGAAGGAGATCTCATGAATGACGACTTG
TACAGCATAGGGACAGCTGCTGGATATCTCGCTGTCTGAAGGAATGGCTGGAGCTCA
AGGAGGAATTTGGGATGTCGTTCAATATCAACTCCCAGGACCAGATGACGAAGCTA
15 GAGGAGTCATGAATACAGTCGGAGCTATGGGAGGGTGGACAAGAGCTGTCACTCC
TGTCGATAACGTCGCTACAATGAGAGATAATGGAGTCGAAGGAGAGCCATGCGGG
ATTGTCATGAGCCTCCCTACTAGCGGAACAGCAGTCGTCGACAGACTCGCAAACCTT
TGGGCTCCCTCCTGCTAGAGCTGAGCTCCGCGAGGTCCCTTTCGGAGGATATCAGC
GCAGCGTTACTAATACAAATCATCGCGTTAAAGTCAGCGTCAGCGGAGGAAGAGC
20 TGTCGTCCAGAAGGGAAATAAGGCTGAAATGAACCCTGTTTTCGTTAACAGAACTC
CTGGGCAGACAACACTCGGACAGCCTACTACTGATACAACCTGGAATGACTACAGCT
GACTTCCTCGACATTTAA (SEQ ID NO: 4)

ATGTCCAATAAAAATGAAAAGCTTCCTGCTCGTCCTGCTGTGCCTGTGTGTGGGCGA
25 GGGAATCGTGCCCATGTTTAGAAGAGAGTGGTGCCTGTGTACCGCTGGAAACGCTA
GGGTGCCACTGGTCGGGGAAGGGAGAGCAGAAAAAATTGAACTGTTTAACCAATC
CGCTACCTGCGGCAAAAAGGAACTGATCATCACCTGGAAAGGGAAAAGATGGTGT
TATGACATCGAATCCAAAAGGGGCAAGATCCTGGTGAAAACCTCTCTGGCGGAG
GCCACCTCGAGAGAGAAGGCAAAGGATATAAACTCGTGAGAAATGGATTTACCT
30 GGCCAGCTTTGGCGGCAAGAAAGAAGAGATCCAAGACTCCAGCCATATCGAAAAG
GTGAATGGCAAGGATGCCATCGTGAAAAAGGGACAGCATGTGGAGCACCTGCCCCG
GAGGCAATGACCTGATCGTGACCGAAGGAGGCAATCTCTGCGGCAATGTCGGATTT
TTTGACAACACCCAATGTACCTATAATTCCGTGATCAACATCGGGGGCGGGTCCGT
GGATAACAGCCAGGAAGCTAAAAATGACAAGAGCAATACCATCGATAACCTGATC

ATGTCCAATAAAATGAAAAGCTTCCCTGCTCGTCCTGCTGTGCCTGTGTGTGGGCCGA
GGGAATCGTGCCCATGTTTAGAAGAGAGTGGTGCCTGTGTACCGCTGGAAACGCTA

10 GGGTGCCACTGGTCGGGGAAGGGAGAGCAGAAAAAATTGAACTGTTTTAACCAATC
CGCTACCTGCCGCAAAAAGGAACTGATCATCACCTGGAAAGGGAAAAGATGGTGT
TATGACATCGGATCCAAAAGGGGCAAGGTCCTGGTGCAAACCCTCTCTGGCGGAG
GCCACCTCGAGCAAGAAGGCAAAGGATATAAACTCGTGAGAAATGGATTTACCT
GGCCAGCTTTGGCGGCAAGAAAGAAGAGATCCAAGACTCCAGCCATATCGAAAAG

15 GTGAATGGCAAGGATGCCATCGTGAAAAAGGGACAGCATGTGGAGCACCTGCCCCG
GAGGCAATGACCTGATCGTGACCGAAGGAGGCAATCTCTGCGGCAATGTCGGATTT
TTTGACAACACCCAATGTACCTATAATTCCGTGATCAACATCGGGGGCGGGTCCGT
GGATAACAGCCAGGAAGCTAAAAATGACAAGAGCAATACCATCGATAACCTGATC
GACATGCTGCCCCTGGTGGTGGGGATCGCTGGCGGATGCCTGATCGTCATCGTGAT

20 ACTGTATCTGACCATCAAGTATTGCAAGTGTAAGAAAAAAAAAGAACAAATCCTGAG
CCCGTTGAGCCAGAAGAGCATGAAATGAGAGACCTGAGACGCAGACTGGAACCTA
GGCCACCCTATCAGAGGCAAATGGGCGTGGAATTCGAGATCAACGAGGCCCTGGA
GTTTATGGGAGTGGAGGGATCCGAGTCTCCTGATTCCGGGTGTCAAAGCGACGAGG
AAGGCTTTAGGGTGGGGGTGTGA (SEQ ID NO: 6)

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Exemplary Vectors

16

WHAT IS CLAIMED IS:

1. A codon optimized nucleic acid sequence comprising SEQ ID NO:1.
2. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:1.
- 5 3. A codon optimized nucleic acid sequence consisting of SEQ ID NO:1.
4. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:1.
5. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:1.
- 10 6. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:1.
7. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:1.
8. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:1.
- 15 9. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:1.
10. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:1.
- 20 11. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:1.
12. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:1.
13. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:1.
- 25 14. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:1.
15. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:1.
- 30 16. A codon optimized nucleic acid sequence comprising SEQ ID NO:2.
17. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:2.
18. A codon optimized nucleic acid sequence consisting of SEQ ID NO:2.

19. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:2.
20. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:2.
- 5 21. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:2.
22. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:2.
23. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:2.
- 10 24. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:2.
25. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:2.
- 15 26. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:2.
27. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:2.
28. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:2.
- 20 29. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:2.
30. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:2.
- 25 31. A codon optimized nucleic acid sequence comprising SEQ ID NO:3.
32. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:3.
33. A codon optimized nucleic acid sequence consisting of SEQ ID NO:3.
34. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:3.
- 30 35. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:3.
36. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:3.

37. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:3.
38. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:3.
- 5 39. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:3.
40. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:3.
41. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:3.
- 10 42. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:3.
43. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:3.
- 15 44. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:3.
45. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:3.
46. A codon optimized nucleic acid sequence comprising SEQ ID NO:4.
- 20 47. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:4.
48. A codon optimized nucleic acid sequence consisting of SEQ ID NO:4.
49. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:4.
- 25 50. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:4.
51. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:4.
52. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:4.
- 30 53. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:4.
54. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:4.

55. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:4.
56. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:4.
- 5 57. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:4.
58. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:4.
59. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:4.
- 10 60. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:4.
61. A codon optimized nucleic acid sequence comprising SEQ ID NO:5.
62. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:5.
- 15 63. A codon optimized nucleic acid sequence consisting of SEQ ID NO:5.
64. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:5.
65. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:5.
- 20 66. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:5.
67. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:5.
- 25 68. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:5.
69. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:5.
70. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:5.
- 30 71. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:5.
72. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:5.

73. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:5.
74. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:5.
- 5 75. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:5.
76. A codon optimized nucleic acid sequence comprising SEQ ID NO:6.
77. A codon optimized nucleic acid sequence consisting essentially of SEQ ID NO:6.
- 10 78. A codon optimized nucleic acid sequence consisting of SEQ ID NO:6.
79. A codon optimized nucleic acid sequence comprising a sequence at least 80% identical with SEQ ID NO:6.
80. A codon optimized nucleic acid sequence comprising a sequence at least 85% identical with SEQ ID NO:6.
- 15 81. A codon optimized nucleic acid sequence comprising a sequence at least 90% identical with SEQ ID NO:6.
82. A codon optimized nucleic acid sequence comprising a sequence at least 91% identical with SEQ ID NO:6.
83. A codon optimized nucleic acid sequence comprising a sequence at least 92% identical with SEQ ID NO:6.
- 20 84. A codon optimized nucleic acid sequence comprising a sequence at least 93% identical with SEQ ID NO:6.
85. A codon optimized nucleic acid sequence comprising a sequence at least 94% identical with SEQ ID NO:6.
- 25 86. A codon optimized nucleic acid sequence comprising a sequence at least 95% identical with SEQ ID NO:6.
87. A codon optimized nucleic acid sequence comprising a sequence at least 96% identical with SEQ ID NO:6.
88. A codon optimized nucleic acid sequence comprising a sequence at least 97% identical with SEQ ID NO:6.
- 30 89. A codon optimized nucleic acid sequence comprising a sequence at least 98% identical with SEQ ID NO:6.
90. A codon optimized nucleic acid sequence comprising a sequence at least 99% identical with SEQ ID NO:6.

91. An expression vector comprising one or more codon optimized nucleic acids sequences, wherein the one or more codon optimized nucleic acids sequences are selected from any one of claims 1 to 90 and any combination thereof.

92. An immunogenic composition comprising the expression vector of claim 91.

5 93. A plurality of expression vectors, wherein at least one expression vector comprises the one or more codon optimized nucleic acids sequences are selected from any one of claims 1 to 90.

94. An immunogenic composition comprising the plurality of expression vectors of claim 93.

10 95. A method of immunizing a non-human animal with the immunogenic composition of claim 94.

96. The method of claim 95, wherein the non-human animal is a fish.