Claims

1. An adeno associated virus (AAV) capsid protein,

wherein the capsid protein comprises one or more of the following substitutions, wherein the amino acids are numbered according to the amino acid sequence of SEQ ID NO:8:

a) a substitution of the amino acids corresponding to amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488), a substitution of the amino acids corresponding to amino acids 455-461 with the sequence VNTSING (SEQ ID NO:489), or a substitution of the amino acids corresponding to amino acids 455-461 with the sequence IRGAGAV (SEQ ID NO:490);

b) a substitution of the amino acids corresponding to amino acids 494-501 with the sequence YPGGNYK (SEQ ID NO:491); and/or

c) a substitution of the amino acids corresponding to amino acids 586-591 with the sequence KQKNVN (SEQ ID NO:492) or RMSSIK (SEQ ID NO:493).

2. The capsid protein of claim 1, wherein the capsid protein further comprises a substitution at amino acid 453, 454, 502, 592, 593, 594, 595, 596, 597, 598, 599 and/or 600, in any combination.

3. The capsid protein of claim 1, wherein the capsid protein comprises a substitution of amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488) and a substitution of amino acids 494-501 with the sequence YPGGNYK (SEQ ID NO:491).

4. The capsid protein of claim 1, wherein the capsid protein comprises a substitution of amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488) and a substitution of amino acids 494-501 with the sequence KQKNVN (SEQ ID NO:492).

5. An adeno associated virus (AAV) capsid protein, wherein the capsid protein comprises a substitution of amino acids corresponding to amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488), wherein the amino acids are numbered according to the amino acid sequence of SEQ ID NO:8.

6. An adeno-associated virus (AAV) capsid protein, wherein the capsid protein comprises one or more of the following substitutions, wherein the amino acids are numbered according to the amino acid sequence of SEQ ID NO:8:

a) a substitution of the amino acids corresponding to amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488), a substitution of the amino acids corresponding to amino acids 455-461 with the sequence VNTSING (SEQ ID NO:489), or a substitution of the amino acids corresponding to amino acids 455-461 with the sequence IRGAGAV (SEQ ID NO:490);

b) a substitution of the amino acids corresponding to amino acids 494-501 with the sequence YPGGNYK (SEQ ID NO:491); and/or

c) a substitution of the amino acids corresponding to amino acids 586-591 with the sequence KQKNVN (SEQ ID NO:492) or RMSSIK (SEQ ID NO:493), and

wherein the capsid protein with the substitutions of one or more of a)-c) is at least about 90% identical to the amino acid sequence of SEQ ID NO:8.

7. An adeno associated virus (AAV) capsid protein, wherein the capsid protein comprises a substitution of amino acids 455-460 with the sequence SNGRGV (SEQ ID NO:488), wherein the amino acids are numbered according to the amino acid sequence of SEQ ID NO:8, and wherein the capsid protein comprises a sequence at least about 90% identical to the amino acid sequence of SEQ ID NO:8.

8. The capsid protein of claim 6 or 7, wherein the capsid protein comprises a sequence at least about 95% identical to the amino acid sequence of SEQ ID NO:8.

9. The capsid protein of claim 6 or 7, wherein the capsid protein comprises a sequence at least about 97% identical to the amino acid sequence of SEQ ID NO:8.

10. The capsid protein of claim 6 or 7, wherein the capsid protein comprises a sequence at least about 98% identical to the amino acid sequence of SEQ ID NO:8.

11. The capsid protein of claim 6 or 7, wherein the capsid protein comprises a sequence at least about 99% identical to the amino acid sequence of SEQ ID NO:8.

12. The capsid protein of claim 6, wherein the capsid protein comprises one or more substitutions at the amino acids corresponding to amino acids 453-461 and 495-502 of SEQ ID NO:8.

13. The capsid protein of claim 6, wherein the capsid protein comprises one or more substitutions at the amino acids corresponding to amino acids 453-461 and 590-600 of SEQ ID NO:8.

14. The capsid protein of claim 6, wherein the capsid protein comprises one or more substitutions at the amino acids corresponding to amino acids 495-502 and 590-600 of SEQ ID NO:8.

15. The capsid protein of claim 6, wherein the capsid protein comprises one or more substitutions at the amino acids corresponding to amino acids 453-461, 495-502 and 590-600 of SEQ ID NO:8.

16. The capsid protein of claim 6, wherein the capsid protein comprises a substitution of amino acids 455-460 of SEQ ID NO:8 with the sequence SNGRGV (SEQ ID NO:488) and a substitution of amino acids 494-501 of SEQ ID NO:8 with the sequence YPGGNYK (SEQ ID NO:491).

17. The capsid protein of claim 6, wherein the capsid protein comprises a substitution of amino acids 455-460 of SEQ ID NO:8 with the sequence SNGRGV (SEQ ID NO:488) and a substitution of amino acids 494-501 of SEQ ID NO:8 with the sequence KQKNVN (SEQ ID NO:492).

18. A polynucleotide encoding the capsid protein of any one of claims 1 to 17.

19. The polynucleotide of claim 18, wherein the polynucleotide is DNA.

20. The polynucleotide of claim 18, wherein the polynucleotide is RNA.

21. An expression vector comprising the polynucleotide of any one of claims 18 to 20.

22. A cell comprising the polynucleotide of any one of claims 18 to 20.

23. A cell comprising the expression vector of claim 21.

24. A method of producing an adeno-associated virus (AAV) capsid protein, the method comprising: culturing the cell of claim 22 or 23 under conditions such that the cell expresses the capsid protein.

25. The method of claim 24, further comprising collecting the capsid protein from the cell.

26. A method of producing an adeno-associated virus (AAV) vector comprising the capsid protein of any one of claims 1 to 17, the method comprising culturing a cell that comprises (i) the polynucleotide of any one of claims 18 to 20, (ii) a polynucleotide comprising 5' inverted terminal repeat (ITR), a heterologous nucleic acid sequence, and a 3' ITR, and (iii) AAV sequences sufficient for replication and encapsidation of polynucleotide, wherein the cell is cultured under conditions such that it produces the AAV vector.

27. The method of claim 26, further comprising collecting the AAV vector from the cell.