

CLAIMS

What is claimed is:

- 5 1. An AAV capsid protein comprising at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32 or at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.
- 10 2. The AAV capsid protein of claim 1, wherein the AAV capsid protein comprises serotype AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, or AAVrh74.
- 15 3. The AAV capsid protein of claim 2, wherein the AAV capsid protein comprises serotype AAV2.
4. The AAV capsid protein of claim 3, wherein the AAV capsid comprises SEQ ID NO: 207.
- 20 5. The AAV capsid protein of claim 4, wherein the AAV capsid further comprises SEQ ID NO: 90.
6. The AAV capsid protein of claim 5, wherein SEQ ID NO: 90 is inserted into SEQ ID NO: 207 at a hypervariable and/or surface exposed loop of the AAV
25 capsid protein.
7. The AAV capsid protein of claim 6, wherein the surface exposed loop comprises any of the VR-I, VR-II, VR-III, VR-IV, VR-V, VR-VI, VR-VII, VR-VIII and VR-IX regions of the capsid protein.
- 30 8. The AAV capsid protein of claim 6, wherein SEQ ID NO: 90 is inserted into SEQ ID NO: 207 at amino acid position 588.
9. The AAV capsid protein of claim 1, wherein the amino acid sequence is

inserted into any of the VR-I, VR-II, VR-III, VR-IV, VR-V, VR-VI, VR-VII, VR-VIII and VR-IX regions of the capsid protein.

5 10. The AAV capsid protein of claim 1, wherein the amino acid sequence is inserted to any one or more of the VP1, VP2, and VP3 capsid proteins.

11. The AAV capsid of claim 2, wherein SEQ ID NO: 90 is inserted into any one of the serotypes AAV1, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.

10 12. The AAV capsid of claim 11, wherein AAV1 comprises SEQ ID NO: 206, and wherein SEQ ID NO: 90 is inserted into serotype AAV1 at amino acid position 590.

15 13. The AAV capsid of claim 11, wherein AAV3b comprises SEQ ID NO: 208, and wherein SEQ ID NO: 90 is inserted into serotype AAV3b at amino acid position 589.

20 14. The AAV capsid of claim 11, wherein AAV5 comprises SEQ ID NO: 209, and wherein SEQ ID NO: 90 is inserted into serotype AAV5 at amino acid position 578.

25 15. The AAV capsid of claim 11, wherein AAV6 comprises SEQ ID NO: 210, and wherein SEQ ID NO: 90 is inserted into AAV6 serotype at amino acid position 454 or 590.

16. The AAV capsid protein of claim 11, wherein AAV8 comprises SEQ ID NO: 211, and wherein SEQ ID NO: 90 is inserted into AAV8 serotype at amino acid position 591.

30 17. The AAV capsid protein of claim 11, wherein AAV9 comprises SEQ ID NO: 212, and wherein SEQ ID NO: 90 is inserted into any one of amino acid positions 266, 455, or 589.

35 18. The AAV capsid of claim 3, wherein SEQ ID NO: 90 is inserted into

serotype AAV2.

19. An AAV capsid protein, comprising an amino acid sequence set forth in any one of SEQ ID NO: 1-32 or in any one of SEQ ID NO: 68-110, wherein the amino acid sequence is inserted into the AAV capsid protein between amino acid positions 450 and 600.

20. The AAV capsid protein of claim 19, wherein the amino acid sequence is inserted into the AAV capsid protein at amino acid position 588.

21. The AAV capsid protein of claim 19, wherein the amino acid sequence comprises SEQ ID NO: 90.

22. The AAV capsid protein of claim 19, wherein the AAV capsid protein comprises serotype AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, or AAVrh74.

23. An AAV capsid protein, comprising an amino acid sequence set forth in any one of SEQ ID NO: 1-32 or in any one of SEQ ID NO: 68-110, wherein the amino acid sequence is inserted into the AAV capsid protein at amino acid position 266, 454, 455, 578, 588, 589, 590, or 591.

24. The AAV capsid protein of claim 23, wherein the amino acid sequence comprises SEQ ID NO: 90.

25. The AAV capsid protein of claim 23, wherein the AAV capsid protein comprises serotype AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, or AAVrh74.

~~1. A method of identifying an AAV capsid variant with a desired characteristic compared to a natural AAV serotype, comprising:~~

~~(i) contacting a cell, cell line, or tissue with a library of AAV variants, wherein each member of the library comprises:~~

a) a nucleic acid encoding an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface-exposed loop of the variant capsid protein; and

one or more of:

b) one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a);

c) a nucleic acid encoding a localization signal;

d) a nucleic acid comprising a barcode; and

e) a nucleic acid encoding a reporter protein;

(ii) allowing the AAV variants in said library to transduce the cell, cell line, or tissue;

(iii) recovering from the cell, cell line, or tissue the AAV variant; and

(iv) identifying the AAV capsid variant with the desired characteristic.

2. A method of identifying an AAV capsid variant with a desired characteristic

compared to a natural AAV serotype, comprising:

(i) contacting a cell, cell line, or tissue with a library of AAV variants, wherein each member of the library comprises:

a) an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface-exposed loop of the variant capsid protein;

and one or more of:

b) one or more silent mutations in the nucleic acid encoding the AAV variant capsid protein of a) in the nucleic acid sequence flanking the peptide insertion site;

c) a nucleic acid encoding a localization signal;

d) a nucleic acid comprising a barcode; and

e) a nucleic acid encoding a reporter protein;

(ii) allowing the AAV variants in said library to transduce the cell, cell line, or tissue;

(iii) recovering from the cell, cell line, or tissue the AAV variant; and

(iv) identifying the AAV capsid variant with the desired characteristic.

3. The method of claim 1, wherein each member of the library comprises one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a).

4. The method of claim 2, wherein each member of the library comprises one or more silent mutations in the nucleic acid encoding the AAV variant capsid protein of a) in the nucleic acid sequence flanking the peptide insertion site.
5. The method of any one of claims 1-4, wherein each member of the library comprises a nucleic acid encoding a localization signal.
6. The method of any one of claims 1-5, wherein each member of the library comprises a nucleic acid comprising a barcode.
7. The method of any one of claims 1-6, wherein each member of the library comprises a nucleic acid encoding a reporter protein.
8. The method of any one of claims 1-7, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in separate nucleic acid molecules.
9. The method of any one of claims 1-7, wherein the nucleic acid encoding an AAV variant capsid protein, the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in one nucleic acid molecule.
10. The method of claim 9, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are linked to each other in any order.
11. The method of claim 10, wherein each member of the library comprises: a 5' ITR sequence, the nucleic acid comprising a barcode, the nucleic acid encoding a reporter protein, the nucleic acid encoding an AAV variant capsid protein, and a 3' ITR sequence, in that order.
12. The method of any one of claims 1-11, wherein the library of AAV variants comprises AAV variant capsid proteins derived from two or more AAV serotypes.

13. The method of any one of claims 1-12, wherein the AAV serotype of the library of AAV variants is selected from one or more of: AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.

14. The method of any one of claims 1-13, wherein the nucleic acid encoding the reporter protein and the nucleic acid encoding an AAV variant capsid are each independently operatively linked to a promoter.

15. The method of any one of claims 1-14, wherein the desired characteristic is enhanced cell or tissue tropism.

16. A method of identifying an AAV capsid variant with a desired characteristic compared to a natural AAV serotype, comprising:

(i) inserting a plurality of nucleic acids encoding peptides, into a population of nucleic acids encoding a hypervariable and/or surface-exposed loop of an AAV capsid protein to create a library of nucleic acids encoding AAV variant capsid proteins;

(ii) linking each nucleic acid encoding an AAV variant capsid protein in said library to one or more of:

- (a) a nucleic acid comprising a barcode,
- (b) a nucleic acid encoding a reporter protein, and
- (c) a nucleic acid encoding a localization signal;

(iii) manufacturing a library of AAV variants in producer cells by providing adenovirus helper and AAV rep functions *in trans*;

(iv) purifying the library of AAV variants;

(v) contacting a cell, cell line, or tissue with the library of AAV variants;

(vi) recovering the AAV variants from the target cell, cell line, or tissue; and

(vii) identifying the AAV capsid variant with the desired characteristic.

17. The method of claim 16, wherein each nucleic acid encoding an AAV variant capsid protein in said library is linked to a nucleic acid comprising a barcode.

18. The method of any one of claims 1-17, wherein each member of the library comprises a first nucleic acid comprising a first barcode and a second nucleic acid comprising a second barcode.

19. The method of claim 18, wherein the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode are different.

20. The method of claim 18 or 19, wherein the first nucleic acid comprising the first barcode comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.

21. The method of claim 18 or 19, wherein the first nucleic acid comprising the first barcode is selected from any one of sequences SEQ ID NO: 111-154.

22. The method of claim 18 or 19, wherein the second nucleic acid comprising the second barcode comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.

23. The method of claim 18 or 19, wherein the second nucleic acid comprising the second barcode is selected from any one of sequences SEQ ID NO: 155-198.

24. The method of any one of claims 18-23, wherein each of the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode is independently operatively linked to a promoter.

25. The method of claim 24, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol II promoter.

26. The method of claim 24, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the nucleic acid comprising the second barcode is each independently an RNA Pol III promoter.

27. The method of claim 24, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode is an RNA Pol II promoter and the promoter operatively linked to the second nucleic acid comprising the second barcode is an RNA Pol III promoter.

28. The method of any one of claims 25-27, wherein each RNA Pol II promoter is independently selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc-45 myosin

chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG binding protein 2 (MeCP2) promoter.

29. The method of any one of claims 26-27, wherein each RNA Pol III promoter is independently selected from the group consisting of U6 promoter, H1 promoter and 7SK promoter.

30. The method of any one of claims 16-29, wherein each nucleic acid encoding an AAV variant capsid protein in said library is linked to a nucleic acid encoding a reporter protein.

31. The method of any one of claims 16-30, wherein each nucleic acid encoding an AAV variant capsid protein in said library is linked to a nucleic acid encoding a localization signal.

32. The method of any one of claims 16-31, wherein each nucleic acid encoding an AAV variant capsid protein further comprises one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site.

33. The method of any one of claims 16-32, wherein step (iv) further comprises combining libraries of variant AAVs based on two or more AAV serotypes to generate a single pool.

34. The method of any one of claims 16-33, wherein the population of nucleic acid sequences encoding a hypervariable and/or surface-exposed loop of an AAV capsid protein comprises sequences derived from two or more AAV serotypes.

35. The method of any one of claims 16-34, wherein the AAV serotype is selected from one or more of: AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.

36. The method of any one of claims 16-35, wherein the helper functions comprise one or more of E2A, E4, VA, E1A, and E1B.

37. The method of any one of claims 16-36, wherein the AAV rep function comprises rep78, rep68, rep52 and rep40 genes.

38. The method of claim 37, wherein the start codon of the rep78 and/or rep68 gene is modified from ACG to ATG.

39. The method of any one of claims 16-38, wherein the producer cells are HEK293 cells.

5 40. The method of any one of claims 16-39, wherein the nucleic acid encoding an AAV variant capsid protein, the nucleic acid comprising a barcode, the nucleic acid encoding a reporter protein, and/or a nucleic acid encoding a localization signal are linked to each other in any order.

10 41. The method of any one of claims 16-40, wherein each member of the library comprises: a 5' ITR sequence, the nucleic acid comprising a barcode, the nucleic acid encoding a reporter protein, the nucleic acid encoding an AAV variant capsid protein, and a 3' ITR sequence, in that order.

15 42. The method of any one of claims 16-41, wherein the nucleic acid encoding a reporter protein and the nucleic acid encoding an AAV variant capsid are each independently operatively linked to a promoter.

43. The method of any one of claims 16-42, wherein the desired characteristic is enhanced cell or tissue tropism.

44. The method of any one of claims 1-43, wherein the peptide has a length of 4-15 amino acids.

20 45. The method of any one of claims 1-44, wherein the peptide has a length of 6-15 amino acids.

46. The method of claim 45, wherein the peptide has a length of 7, 10, or 15 amino acids.

47. The method of claim 46, wherein the peptide has a length of 7 amino acids.

25 48. The method of any one of claims 1-47, wherein the peptide is inserted into a region selected from the group consisting of VR-I, VR-II, VR-III, VR-IV, VR-V, VR-VI, VR-VII, VR-VIII and VR-IX region of the capsid protein.

49. The method of claim 48, wherein the peptide is inserted into the VR-I of the capsid protein.

50. The method of claim 48, wherein the peptide is inserted into the VR-IV of the capsid protein.

5 51. The method of claim 48, wherein the peptide is inserted into the VR-VIII of the capsid protein.

52. The method of any one of claims 1-49, wherein the peptide is inserted into the capsid protein VP1, VP2, or VP3.

10 53. The method of any one of claims 1-50, wherein the peptide is inserted at a location between amino acid residues 450 and 600 of the capsid protein.

54. The method of any one of claims 1-51, wherein

(i) the AAV serotype is AAV1 and the peptide is inserted at amino acid position 590 of the capsid protein,

15 (ii) the AAV serotype is AAV6 and the peptide is inserted at amino acid position 454 or 590 of the capsid protein,

(iii) the AAV serotype is AAV2 and the peptide is inserted at amino acid position 588 of the capsid protein,

(iv) the AAV serotype is AAV3B and the peptide is inserted at amino acid position 589 of the capsid protein,

20 (v) the AAV serotype is AAV5 and the peptide is inserted at amino acid position 578 of the capsid protein,

(vi) the AAV serotype is AAV8 and the peptide is inserted at amino acid position 591 of the capsid protein, or

25 (vii) the AAV serotype is AAV9 and the peptide is inserted at amino acid position 266, 455, or 589 of the capsid protein,

wherein the positions correspond to the numbering of VP1 in the AAV serotype.

55. The method of any one of claims 1-54, wherein the reporter protein is a fluorescent protein.

56. The method of claim 55, wherein the reporter protein is selected from the group consisting of: EGFP, mCherry, mClover3, mRuby3, mApple, iRFP, tdTomato, mVenus, YFP, RFP, firefly luciferase, and nanoluciferase.

57. The method of any one of claims 1-56, wherein the nucleic acid encoding an AAV variant capsid protein is operatively linked to a p40 promoter.

58. The method of any one of claims 1-57, wherein the nucleic acid encoding a reporter protein is operatively linked to a cell type and/or tissue specific promoter.

59. The method of claim 58, wherein the cell type and/or tissue specific promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc-45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG binding protein 2 (MeCP2) promoter.

60. The method of claim 59, wherein the cell type and/or tissue specific promoter is the hSyn1 promoter.

61. The method of claim 60, wherein the cell type and/or tissue specific promoter is the TTR promoter.

62. The method of any one of claims 1-61, wherein the reporter protein is fused to the localization signal.

63. The method of claim 62, wherein the localization signal is fused N-terminally, C-terminally or both N-terminally and C-terminally to the reporter protein.

64. The method of any one of claims 1-63, wherein the localization signal is a nuclear localization signal (NLS), a nuclear envelope binding domain or a histone binding domain.

65. The method of claim 64, wherein the NLS is the SV40 NLS.

66. The method of claim 64, wherein the nuclear envelope binding domain is a KASH domain.

67. The method of claim 64, wherein the histone binding domain is H2B.

68. The method of any one of claims 1-67, wherein the nucleic acid comprising the barcode is 5-18 nucleotides long.

69. The method of any one of claims 1-68, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.

70. The method of any one of claims 1-68, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.

71. The method of any one of claims 1-68, wherein the nucleic acid comprising the barcode is selected from any one of sequences SEQ ID NO: 111-154.

72. The method of any one of claims 1-68, wherein the nucleic acid comprising the barcode is selected from any one of sequences SEQ ID NO: 155-198.

73. The method of any one of claims 1-72, wherein the AAV capsid variant with the desired characteristic is identified through sequencing of the associated one or more barcodes.

74. The method of any one of claims 1-73, wherein the AAV capsid variant with the desired characteristic is identified by purification and sequencing of the AAV genome.

75. The method of any one of claims 1-74, wherein the cell, cell line or tissue is selected from the group consisting of CNS, heart, lung, trachea, esophagus, muscle, bone, cartilage, stomach, pancreas, intestine, liver, bladder, kidney, ureter, urethra, uterus, fallopian tube, ovary, testes, prostate, eye, blood, lymph, and oral mucosa.

76. The method of any one of claims 1-74, wherein the cell is selected from: neurons, glial cells, astrocytes, oligodendroglia, microglia, Schwann cells, ependymal cells, hepatocytes, stellate fat storing cells, Kupffer cells, liver endothelial cells, epithelial cells, cardiomyocytes, smooth muscle cells, T cells, B cells, hematopoietic stem cells, and embryonic stem cells.

77. A library of AAV variants, wherein each member of said library comprises:

- a) a nucleic acid sequence encoding an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface-exposed loop of the variant capsid protein; and
one or more of:
- 5 b) one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a);
c) a nucleic acid encoding a localization signal;
d) a nucleic acid comprising a barcode; and
e) a nucleic acid encoding a reporter protein.
- 10 78. A library of AAV variants, wherein each member of said library comprises:
a) an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface-exposed loop of the variant capsid protein; and
one or more of:
b) one or more silent mutations in the nucleic acid encoding the AAV variant
15 capsid protein of a) in the nucleic acid sequence flanking the peptide insertion site;
c) a nucleic acid encoding a localization signal;
d) a nucleic acid comprising a barcode; and
e) a nucleic acid encoding a reporter protein.
- 20 79. The library of claim 77, wherein each member of the library comprises one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a).
80. The library of claim 78, wherein each member of the library comprises one or more silent mutations in the nucleic acid encoding the AAV variant capsid protein of a) in
25 the nucleic acid sequence flanking the peptide insertion site.
81. The library of any one of claims 77-80, wherein each member of the library comprises a nucleic acid encoding a localization signal.
82. The library of any one of claims 77-81, wherein each member of the library comprises a nucleic acid comprising a barcode.

~~83. The library of any one of claims 77-82, wherein each member of the library comprises a first nucleic acid comprising a first barcode and a second nucleic acid comprising a second barcode.~~

5 ~~84. The library of claim 83, wherein the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode are different.~~

~~85. The library of claim 84, wherein the first nucleic acid comprising the first barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.~~

10 ~~86. The library of claim 84, wherein the first nucleic acid comprising the first barcode sequence is selected from any one of sequences SEQ ID NO: 111-154.~~

~~87. The library of claim 84, wherein the second nucleic acid comprising the second barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.~~

15 ~~88. The library of claim 84, wherein the second nucleic acid comprising the second barcode sequence is selected from any one of sequences SEQ ID NO: 155-198.~~

~~89. The library of any one of claims 83-88, wherein each of the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode is independently operatively linked to a promoter.~~

20 ~~90. The library of claim 89, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol II promoter.~~

25 ~~91. The library of claim 89, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol III promoter.~~

~~92. The library of claim 89, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode is operatively linked to an RNA Pol II promoter and~~

the promoter operatively linked to the second nucleic acid comprising the second barcode is an RNA Pol III promoter.

93. The library of any one of claims 90-91, wherein the RNA Pol II promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc-45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG binding protein-2 (MeCP2) promoter.

94. The library of any one of claims 91-93, wherein the RNA Pol III promoter is selected from the group consisting of U6 promoter, H1 promoter and 7SK promoter.

95. The library of any one of claims 77-94, wherein each member of the library comprises a nucleic acid encoding a reporter protein.

96. The library of any one of claims 77-95, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in separate nucleic acid molecules.

97. The library of any one of claims 77-95, wherein the nucleic acid encoding an AAV variant capsid protein, the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in one nucleic acid molecule.

98. The library of claim 97, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are linked to each other in any order.

99. The library of claim 97, wherein each member of the library comprises: a 5' ITR sequence, the nucleic acid comprising a barcode, the nucleic acid encoding a reporter protein, the nucleic acid encoding an AAV variant capsid protein, and a 3' ITR sequence, in that order.

100. The library of any one of claims 77-99, wherein the AAV variants are derived from one or more of: AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.

101. The library of claim 100, wherein the library of AAV variants comprises AAV variant capsid proteins derived from two or more AAV serotypes.

102. The library of any one of claims 77-101, wherein the peptide has a length of 4-15 amino acids.

103. The library of claim 102, wherein the peptide has a length of 6-15 amino acids.

104. The library of claim 103, wherein the peptide has a length of 7, 10, or 15 amino acids.

105. The library of claim 104, wherein the peptide has a length of 7 amino acids.

106. The library of any one of claims 77-105, wherein the peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32.

107. The library of claim 106, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 1-32.

108. The library of any one of claims 77-106, wherein the peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.

109. The library of claim 108, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 68-110.

110. The library of any one of claims 77-109, wherein the peptide is inserted into a region selected from the group consisting of VR-I, VR-II, VR-III, VR-IV, VR-V, VR-VI, VR-VII, VR-VIII and VR-IX region of the capsid protein.

111. The library of claim 110, wherein the peptide is inserted into the VR-I of the capsid protein.

~~112. The library of claim 110, wherein the peptide is inserted into the VR-IV of the capsid protein.~~

~~113. The library of claim 110, wherein the peptide is inserted into the VR-VIII of the capsid protein.~~

5 ~~114. The library of any one of claims 77-113, wherein the peptide is inserted into the capsid protein VP1, VP2, or VP3.~~

~~115. The library of any one of claims 77-114, wherein the peptide is inserted at a location between amino acid residues 450 and 600 of the capsid protein.~~

~~116. The library of any one of claims 77-115, wherein~~

10 ~~(i) the AAV serotype is AAV1 and the peptide is inserted at amino acid position 590 of the capsid protein,~~

~~(ii) the AAV serotype is AAV6 and the peptide is inserted at amino acid position 454 or 590 of the capsid protein,~~

15 ~~(iii) the AAV serotype is AAV2 and the peptide is inserted at amino acid position 588 of the capsid protein,~~

~~(iv) the AAV serotype is AAV3B and the peptide is inserted at amino acid position 589 of the capsid protein,~~

~~(v) the AAV serotype is AAV5 and the peptide is inserted at amino acid position 578 of the capsid protein,~~

20 ~~(vi) the AAV serotype is AAV8 and the peptide is inserted at amino acid position 591 of the capsid protein, or~~

~~(vii) the AAV serotype is AAV9 and the peptide is inserted at amino acid position 266, 455, or 589 of the capsid protein,~~

~~wherein the positions correspond to the numbering of VP1 in the AAV serotype.~~

25 ~~117. The library of any one of claims 77-116, wherein the reporter protein is a fluorescent protein.~~

~~118. The library of claim 117, wherein the reporter protein is selected from the group consisting of: EGFP, mCherry, mClover3, mRuby3, mApple, iRFP, tdTomato, mVenus, YFP, RFP, firefly luciferase, and nanoluciferase.~~

~~119. The library of any one of claims 77-118, wherein the nucleic acid encoding an AAV variant capsid protein is operatively linked to a p40 promoter.~~

~~120. The library of any one of claims 77-119, wherein the nucleic acid encoding a reporter protein is operatively linked to a cell type and/or tissue specific promoter.~~

5 ~~121. The library of claim 120, wherein the cell type and/or tissue specific promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc 45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG binding protein 2 (Meep2) promoter.~~

~~122. The library of claim 121, wherein the cell type and/or tissue specific promoter is the hSyn1 promoter.~~

~~123. The library of claim 121, wherein the cell type and/or tissue specific promoter is the TTR promoter.~~

15 ~~124. The library of any one of claims 77-123, wherein the reporter protein is fused to the localization signal.~~

~~125. The library of claim 124, wherein the localization signal is fused N terminally, C terminally or both N terminally and C terminally to the reporter protein.~~

20 ~~126. The library of any one of claims 77-125, wherein the localization signal is a nuclear localization signal (NLS), a nuclear envelope binding domain or a histone binding domain.~~

~~127. The library of claim 126, wherein the NLS is the SV40 NLS.~~

~~128. The library of claim 126, wherein the nuclear envelope binding domain is a KASH domain.~~

25 ~~129. The library of claim 126, wherein the histone binding domain is H2B.~~

~~130. The library of any one of claims 77-129, wherein the nucleic acid comprising the barcode is 5-18 nucleotides long.~~

131. The library of any one of claims 77-130, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.

5 132. The library of any one of claims 77-130, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.

133. The library of any one of claims 77-132, wherein the nucleic acid comprising the barcode is selected from any one of sequences SEQ ID NO: 111-154.

10 134. The library of any one of claims 77-132, wherein the nucleic acid comprising the barcode is selected from any one of sequences SEQ ID NO: 155-198.

135. An AAV variant comprising:

- 15 a) a nucleic acid sequence encoding an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface exposed loop of the variant capsid protein; and
one or more of:
b) one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a);
c) a nucleic acid encoding a localization signal;
d) a nucleic acid comprising a barcode; and
20 e) a nucleic acid encoding a reporter protein.

136. An AAV variant comprising:

- a) an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface exposed loop of the variant capsid protein; and
one or more of:
25 b) one or more silent mutations in the nucleic acid encoding the AAV variant capsid protein of a) in the nucleic acid sequence flanking the peptide insertion site;
c) a nucleic acid encoding a localization signal;
d) a nucleic acid comprising a barcode; and
30 e) a nucleic acid encoding a reporter protein.

137. The variant of claim 135, wherein the variant comprises one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a).

138. The variant of claim 136, wherein the variant comprises one or more silent mutations in the nucleic acid encoding the AAV variant capsid protein of a) in the nucleic acid sequence flanking the peptide insertion site.

139. The variant of any one of claims 135-136, wherein the variant comprises a nucleic acid encoding a localization signal.

140. The variant of any one of claim 135-139, wherein the variant comprises a nucleic acid comprising a barcode.

141. The variant of any one of claims 138-139, wherein the variant comprises a first nucleic acid comprising a first barcode and a second nucleic acid comprising a second barcode.

142. The variant of claim 141, wherein the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode are different.

143. The variant of claim 142, wherein the first nucleic acid comprising the first barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.

144. The variant of claim 142, wherein the first nucleic acid comprising the first barcode sequence is selected from any one of sequences SEQ ID NO: 111-154.

145. The variant of claim 142, wherein the second nucleic acid comprising the second barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.

146. The variant of claim 142, wherein the second nucleic acid comprising the second barcode sequence is selected from any one of sequences SEQ ID NO: 155-198.

147. The variant of any one of claims 142-146, wherein each of the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode is independently operatively linked to a promoter.

148. The variant of claim 147, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol II promoter.

5 149. The variant of claim 147, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol III promoter.

10 150. The variant of claim 147, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode is operatively linked to an RNA Pol II promoter and the promoter operatively linked to the second nucleic acid comprising the second barcode is an RNA Pol III promoter.

15 151. The variant of any one of claims 148-150, wherein the RNA Pol II promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc 45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG binding protein 2 (MeCP2) promoter.

20 152. The variant of any one of claims 149-151, wherein the RNA Pol III promoter is selected from the group consisting of U6 promoter, H1 promoter and 7SK promoter.

153. The variant of any one of claim 135-152, wherein the variant comprises a nucleic acid encoding a reporter protein.

25 154. The variant of any one of claims 135-153, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in separate nucleic acid molecules.

30 155. The variant of any one of claims 135-154, wherein the nucleic acid encoding an AAV variant capsid protein, the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are located in one nucleic acid molecule.

~~156. The variant of claim 155, wherein the nucleic acid encoding an AAV variant capsid protein, and the nucleic acid encoding a localization signal, the nucleic acid comprising a barcode, and/or the nucleic acid encoding a reporter protein, are linked to each other in any order.~~

5 ~~157. The variant of claim 156, wherein the variant comprises: a 5' ITR sequence, the nucleic acid comprising a barcode, the nucleic acid encoding a reporter protein, the nucleic acid encoding an AAV variant capsid protein, and a 3' ITR sequence, in that order.~~

10 ~~158. The variant of any one of claims 135-157, wherein the AAV variant is derived from the group consisting of: AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.~~

~~159. The variant of any one of claims 135-158, wherein the peptide has a length of 4-15 amino acids.~~

~~160. The variant of claim 159, wherein the peptide has a length of 6-15 amino acids.~~

15 ~~161. The variant of claim 160, wherein the peptide has a length of 7, 10, or 15 amino acids.~~

~~162. The variant of claim 161, wherein the peptide has a length of 7 amino acids.~~

20 ~~163. The variant of any one of claims 135-162, wherein the inserted peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

~~164. The variant of claim 163, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

25 ~~165. The variant of any one of claims 135-162, wherein the inserted peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.~~

~~166. The variant of claim 165, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 68-110.~~

~~167. The variant of any one of claims 135-166, wherein the peptide is inserted into a region selected from the group consisting of VR-I, VR-II, VR-III, VR-IV, VR-V, VR-VI, VR-VII, VR-VIII and VR-IX region of the capsid protein.~~

5 ~~168. The variant of claim 167, wherein the peptide is inserted into the VR-I of the capsid protein.~~

~~169. The variant of claim 167, wherein the peptide is inserted into the VR-IV of the capsid protein.~~

~~170. The variant of claim 168, wherein the peptide is inserted into VR-VIII of the capsid protein.~~

10 ~~171. The variant of any one of claims 135-170, wherein the peptide is inserted into the capsid protein VP1, VP2, or VP3.~~

~~172. The variant of any one of claims 135-171, wherein the peptide is inserted at a location between amino acid residues 450 and 600 of the capsid protein.~~

~~173. The variant of any one of claims 135-172, wherein~~

15 ~~(i) the AAV serotype is AAV1 and the peptide is inserted at amino acid position 590 of the capsid protein,~~

~~(ii) the AAV serotype is AAV6 and the peptide is inserted at amino acid position 454 or 590 of the capsid protein,~~

20 ~~(iii) the AAV serotype is AAV2 and the peptide is inserted at amino acid position 588 of the capsid protein,~~

~~(iv) the AAV serotype is AAV3B and the peptide is inserted at amino acid position 589 of the capsid protein,~~

~~(v) the AAV serotype is AAV5 and the peptide is inserted at amino acid position 578 of the capsid protein,~~

25 ~~(vi) the AAV serotype is AAV8 and the peptide is inserted at amino acid position 591 of the capsid protein, or~~

~~(vii) the AAV serotype is AAV9 and the peptide is inserted at amino acid position 266, 455, or 589 of the capsid protein,~~

~~wherein the positions correspond to the numbering of VP1 in the AAV serotype.~~

174. The variant of any one of claims 135-173, wherein the reporter protein is a fluorescent protein.

175. The variant of claim 174, wherein the reporter protein is selected from the group consisting of: EGFP, mCherry, mClover3, mRuby3, mApple, iRFP, tdTomato, mVenus, YFP, RFP, firefly luciferase, and nanoluciferase.

176. The variant of any one of claims 135-175, wherein the nucleic acid encoding an AAV variant capsid protein is operatively linked to a p40 promoter.

177. The variant of any one of claims 138-176, wherein the nucleic acid encoding a reporter protein is operatively linked to a cell type and/or tissue specific promoter.

178. The variant of claim 177, wherein the cell type and/or tissue specific promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc 45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG-binding protein 2 (MeCP2) promoter.

179. The variant of claim 178, wherein the cell type and/or tissue specific promoter is the hSyn1 promoter.

180. The variant of claim 178, wherein the cell type and/or tissue specific promoter is the TTR promoter.

181. The variant of any one of claims 135-180, wherein the reporter protein is fused to the localization signal.

182. The variant of claim 181, wherein the localization signal is fused N-terminally, C-terminally or both N-terminally and C-terminally to the reporter protein.

183. The variant of any one of claims 135-182, wherein the localization signal is a nuclear localization signal (NLS), a nuclear envelope binding domain or a histone binding domain.

184. The variant of claim 183, wherein the NLS is the SV40 NLS.

185. The variant of claim 183, wherein the nuclear envelope binding domain is a KASH domain.

186. The variant of claim 183, wherein the histone binding domain is H2B.

187. The variant of any one of claims 135-186, wherein the nucleic acid comprising the
5 barcode is 5-18 nucleotides long.

188. The variant of any one of claims 135-187, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.

189. The variant of claim 188, wherein the nucleic acid comprising the barcode is
10 selected from any one of sequences SEQ ID NO: 111-154.

190. The variant of any one of claims 135-187, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.

191. The variant of claim 190, wherein the nucleic acid comprising the barcode is
15 selected from any one of sequences SEQ ID NO: 155-198.

192. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV1.

193. The variant of claim 192, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 68
20 to SEQ ID NO: 75.

194. The variant of claim 192, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

195. The variant of claim 192, wherein the variant comprises a peptide comprising the
25 amino acid sequence SEQ ID NO: 71.

196. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV2.

197. The variant of claim 196, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 90 to SEQ ID NO: 110.

5 198. The variant of claim 196, wherein the variant comprises a peptide comprising any one of the sequences selected from the group consisting of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

10 199. The variant of claim 196, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 4-7.

200. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV3B.

15 201. The variant of claim 200, wherein the variant comprises a peptide comprising any one of the sequences selected from the group consisting of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

202. The variant of claim 200, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 8 to SEQ ID NO: 11.

20 203. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV5.

204. The variant of claim 203, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 28 to SEQ ID NO: 32.

25 205. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV6.

206. The variant of claim 205, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of consisting of any one of SEQ ID NO: 19 to SEQ ID NO: 27.

207. The variant of any one of claims 135-191, wherein the AAV variant is derived from AAV9.

208. The variant of claim 207, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 12 to SEQ ID NO: 18.

209. The variant of claim 207, wherein the variant comprises a peptide comprising an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 86 to SEQ ID NO: 89.

210. The variant of claim 207, wherein the variant comprises a peptide comprising the sequence SEQ ID NO: 89.

211. A nucleic acid molecule comprising:

- a) a nucleic acid sequence encoding an AAV variant capsid protein comprising a peptide inserted into a hypervariable and/or surface exposed loop of the variant capsid protein; and
- one or more of:
 - b) a nucleic acid sequence encoding a variant capsid protein comprising one or more silent mutations in the nucleotide sequence flanking the peptide insertion site in the hypervariable and/or surface exposed loop of the variant capsid protein;
 - c) a nucleic acid sequence encoding a localization signal;
 - d) a nucleic acid sequence comprising a barcode; and
 - e) a nucleic acid sequence encoding a reporter protein.

212. The nucleic acid molecule of claim 211, wherein the nucleic acid sequence encoding an AAV variant capsid protein comprises one or more silent mutations in the nucleic acid sequence flanking the peptide insertion site in the AAV variant capsid protein of a).

213. The nucleic acid molecule of claim 212, wherein the nucleic acid molecule comprises a nucleic acid encoding a localization signal.

~~214. The nucleic acid molecule of claim 212, wherein the nucleic acid molecule comprises a nucleic acid comprising a barcode.~~

~~215. The nucleic acid molecule of claims 211-214, wherein the nucleic acid molecule comprises a first nucleic acid comprising a first barcode and a second nucleic acid comprising a second barcode.~~

~~216. The nucleic acid molecule of claim 215, wherein the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode are different.~~

~~217. The nucleic acid molecule of claim 216, wherein the first nucleic acid comprising the first barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.~~

~~218. The nucleic acid molecule of claim 217, wherein the first nucleic acid comprising the first barcode sequence is selected from any one of sequences SEQ ID NO: 111-154.~~

~~219. The nucleic acid molecule of claim 216, wherein the second nucleic acid comprising the second barcode sequence comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.~~

~~220. The nucleic acid molecule of claim 217, wherein the second nucleic acid comprising the second barcode sequence is selected from any one of sequences SEQ ID NO: 155-198.~~

~~221. The nucleic acid molecule of any one of claims 215-220, wherein each of the first nucleic acid comprising the first barcode and the second nucleic acid comprising the second barcode is independently operatively linked to a promoter.~~

~~222. The nucleic acid molecule of claim 221, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked to the second nucleic acid comprising the second barcode is each independently an RNA Pol II promoter.~~

~~223. The nucleic acid molecule of claim 221, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode and the promoter operatively linked~~

to the second nucleic acid comprising the second barcode is each independently an RNA Pol III promoter.

224. The nucleic acid molecule of claim 221, wherein the promoter operatively linked to the first nucleic acid comprising the first barcode is operatively linked to an RNA Pol II promoter and the promoter operatively linked to the second nucleic acid comprising the second barcode is an RNA Pol III promoter.

225. The nucleic acid molecule of any one of claims 222-224, wherein the RNA Pol II promoter is selected from the group consisting of: human synapsin promoter (hSyn1), transthyretin promoter (TTR), cytokeratin 18, cytokeratin 19, unc-45 myosin chaperon B (unc45b) promoter, cardiac troponin T (cTnT) promoter, glial fibrillary acidic protein (GFAP) promoter, myelin basic protein (MBP) promoter, and methyl CpG-binding protein 2 (MeCP2) promoter.

226. The nucleic acid molecule of any one of claims 223-224, wherein the RNA Pol III promoter is selected from the group consisting of U6 promoter, H1 promoter and 7SK promoter.

227. The nucleic acid molecule of any one of claims 211-226, where the nucleic acid molecule comprises a nucleic acid encoding a reporter protein.

228. The nucleic acid molecule of any one of claims 211-227, wherein the AAV variants are derived from one or more of: AAV1, AAV2, AAV3B, AAV5, AAV6, AAV8, AAV9, AAV3, AAV4, AAV7, AAV11, AAVrh10, AAVrh39, and AAVrh74.

229. The nucleic acid molecule of any one of claims 211-228, wherein the inserted peptide has a length of 4-15 amino acids.

230. The nucleic acid molecule of claim 229, wherein the inserted peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32.

231. The nucleic acid molecule of claim 229, wherein the inserted peptide comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.

~~232. The nucleic acid molecule of any one of claims 211-231, wherein the nucleic acid encoding a reporter protein is operatively linked to a cell type and/or tissue specific promoter.~~

5 ~~233. The nucleic acid molecule of claim 232, wherein the cell type and/or tissue specific promoter is the hSyn1 promoter.~~

~~234. The nucleic acid molecule of any one of claims 211-233, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 111-154.~~

10 ~~235. The nucleic acid molecule of any one of claims 211-233, wherein the nucleic acid comprising the barcode comprises a sequence selected from any one of sequences SEQ ID NO: 155-198.~~

~~236. Use of an AAV variant according to any one of claims 135-210 to deliver a transgene to a target cell or tissue.~~

15 ~~237. An AAV vector comprising a nucleic acid molecule encoding a peptide that comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

~~238. The AAV vector of claim 237, wherein the nucleic acid encodes a peptide that comprises an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

20 ~~239. The AAV vector of claim 237 or 238, wherein the nucleic acid encodes a peptide having a sequence of any of one of SEQ ID NO: 1-32.~~

~~240. An AAV vector comprising a nucleic acid molecule encoding a peptide that comprises at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.~~

25 ~~241. The AAV vector of claim 240, wherein the nucleic acid encodes a peptide that comprises an amino acid sequence set forth in any one of SEQ ID NO: 68-110.~~

~~242. The AAV vector of claim 240 or 241, wherein the nucleic acid encodes a peptide having the sequence of any of one of SEQ ID NO: 68-110.~~

~~243. The AAV vector of claim 240, wherein the nucleic acid encodes a peptide that comprises an amino acid sequence set forth in any one of SEQ ID NO: 71, 76-80, 83, 89, 91, 94-96, 101-103 and 106.~~

~~244. The AAV vector of any one of claims 237-243, wherein the peptide is a part of a capsid protein.~~

~~245. The AAV vector of claim 244, wherein the capsid protein is VP1, VP2, or VP3.~~

~~246. The AAV vector of any one of claims 237-245, wherein the peptide is inserted at a location between amino acid residues 450 and 600 of the capsid protein.~~

~~247. The AAV vector of claim 246, wherein the peptide is inserted at~~

- ~~(i) amino acid position 590 of an AAV1 capsid protein,~~
- ~~(ii) amino acid position 454 or 590 of an AAV6 capsid protein,~~
- ~~(iii) amino acid position 588 of an AAV2 capsid protein,~~
- ~~(iv) amino acid position 589 of an AAV3B capsid protein,~~
- ~~(v) amino acid position 578 of an AAV5 capsid protein,~~
- ~~(vi) amino acid position 591 of the an AAV8 capsid protein, or~~
- ~~(vi) amino acid position 266, 455, or 589 of an AAV9 capsid protein,~~

~~wherein the positions correspond to the numbering of VP1 in the AAV serotype.~~

~~248. A pharmaceutical composition comprising the AAV vector of any one of claims 237-247 and a pharmaceutically acceptable carrier.~~

~~249. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

~~250. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 68-110.~~

~~251. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 71, 76-80, 83, 89, 91, 94-96, 101-103 and 106.~~

~~252. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 71, 76-80, 83 and 94-96.~~

253. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 89, 91, 101-103 and 106.
254. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 68 to SEQ ID NO: 75.
- 5 255. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.
256. A peptide comprising an amino acid sequence set forth in SEQ ID NO: 71.
257. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 90 to SEQ ID NO: 110.
- 10 258. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.
259. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 4-7.
- 15 260. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.
261. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 8 to SEQ ID NO: 11.
- 20 262. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 28 to SEQ ID NO: 32.
263. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 19 to SEQ ID NO: 27.
264. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 12 to SEQ ID NO: 18.
- 25 265. A peptide comprising an amino acid sequence set forth in any one of SEQ ID NO: 86 to SEQ ID NO: 89.

266. A peptide comprising an amino acid sequence set forth in SEQ ID NO: 89.

267. The peptide of any one of claims 249-266, wherein the peptide is part of an AAV vector.

5 268. The peptide of claim 267, wherein the peptide is part of a capsid protein of the AAV vector.

269. A nucleic acid molecule encoding the peptide of any one of claims 249-268.

270. A capsid protein comprising a peptide comprising at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 1-32.

10 271. A capsid protein comprising a peptide comprising at least 4 contiguous amino acids of an amino acid sequence set forth in any one of SEQ ID NO: 68-110.

272. The capsid protein of claim 270, wherein the peptide comprises the amino acid sequence set forth in any one of SEQ ID NO: 1-32.

273. The capsid protein of claim 271, wherein the peptide comprises the amino acid sequence set forth in any one of SEQ ID NO: 68-110.

15 274. The capsid protein of claim 270, comprising the amino acid sequence set forth in any one of SEQ ID NO: 1-32.

275. The capsid protein of claim 271, comprising the amino acid sequence set forth in any one of SEQ ID NO: 68-110.

20 276. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 71, 76-80, 83, 89, 91, 94-96, 101-103 and 106.

277. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 71, 76-80, 83 and 94-96.

25 278. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 89, 91, 101-103 and 106.

279. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 68 to SEQ ID NO: 75.

280. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

5 281. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in SEQ ID NO: 71.

282. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 90 to SEQ ID NO: 110.

10 283. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

284. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 4-7.

15 285. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

286. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 8 to SEQ ID NO: 11.

20 287. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 28 to SEQ ID NO: 32.

288. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 19 to SEQ ID NO: 27.

25 289. The capsid protein of claim 270, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 12 to SEQ ID NO: 18.

290. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in any one of SEQ ID NO: 86 to SEQ ID NO: 89.

~~291. The capsid protein of claim 271, wherein the peptide comprises an amino acid sequence set forth in SEQ ID NO: 89.~~

~~292. A nucleic acid molecule encoding the capsid protein of any one of claims 269-291.~~

5 ~~293. A method of delivering a nucleic acid to a target cell or tissue of a subject, comprising: administering a composition comprising an AAV vector according to any one of claims 237-247.~~

~~294. The method of claim 293, wherein the capsid protein comprises an amino acid sequence set forth in any one of SEQ ID NO: 1-32.~~

10 ~~295. The method of claim 293, wherein the capsid protein comprises an amino acid sequence set forth in any one of SEQ ID NO:68-110.~~

~~296. The method of any one of claims 293-295, wherein the target cell, cell line or tissue is selected from the group consisting of CNS, heart, lung, trachea, esophagus, muscle, bone, cartilage, stomach, pancreas, intestine, liver, bladder, kidney, ureter, urethra, uterus, fallopian tube, ovary, testes, prostate, eye, blood, lymph, and oral mucosa.~~

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~~297. The method of any one of claims 293-295, wherein the target cell is selected from the group consisting of neurons, glial cells, astrocytes, oligodendroglia, microglia, Schwann cells, ependymal cells, hepatocytes, stellate fat storing cells, Kupffer cells, liver endothelial cells, epithelial cells, cardiomyocytes, smooth muscle cells, T-cells, B cells, hematopoietic stem cells, and embryonic stem cells.~~

20

~~298. The method of claim 296, wherein the target cell or tissue is from liver.~~

~~299. The method of claim 296, wherein the target cell or tissue is from CNS.~~

~~300. A pharmaceutical composition comprising the variant of any one of claims 135-211 and a pharmaceutically acceptable carrier.~~

25

~~301. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.~~

302. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.

5 303. The library of claim 302, wherein the peptide comprises an amino acid sequence of any one of SEQ ID NO: 68-75.

304. The library of claim 302, wherein the peptide comprises the amino acid sequence SEQ ID NO: 71.

10 305. The library of claim 301, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

306. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

15 307. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

308. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

20 309. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

310. The library of any one of claims 306 and 308, wherein the peptide comprises an amino acid sequence of any one of SEQ ID NO: 19 to SEQ ID NO: 27.

25 311. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

312. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

5 313. The library of claim 312, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 90 to SEQ ID NO: 110.

314. The library of claims 312, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

10 315. The library of claims 311, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 4-7.

316. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

15 317. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

318. The library of claim 317, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 76-85.

20 319. The library of claim 317, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

320. The library of claim 316, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 8 to SEQ ID NO: 11.

25 321. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

322. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

5 323. The library of claim 321, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one SEQ ID NO: 28 to SEQ ID NO: 32.

324. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

10 325. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

326. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

15 327. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

20 328. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

329. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

25 330. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

331. The library of claim 116, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

332. The library of any one of claims 326, 328, and 330, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 12 to SEQ ID NO: 18.

5 333. The library of any one of claims 327, 329, and 331, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 86 to SEQ ID NO: 89.

334. The library of any one of claims 327, 329, and 331, wherein the peptide comprises the sequence of SEQ ID NO: 89.

10 335. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.

336. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.

15 337. The AAV variant of claim 336, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 68 to SEQ ID NO: 75.

338. The AAV variant of claim 336, wherein the peptide comprises the amino acid sequence SEQ ID NO: 71.

20 339. The AAV variant of claim 335, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

25 340. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

341. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

342. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

5 343. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

344. The AAV variant of any one of claims 340 and 342, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 19 to SEQ ID NO: 27.

10 345. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of SEQ ID NO: 1-32 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

15 346. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of SEQ ID NO: 68-110 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

347. The AAV variant of claim 346, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 90 to SEQ ID NO: 110.

20 348. The AAV variant of claims 346, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

349. The AAV variant of claims 345, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 4-7.

25 350. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

351. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

5 352. The AAV variant of claim 351, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

353. The AAV variant of claim 350, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 8 to SEQ ID NO: 11.

10 354. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

355. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 578 of
15 the capsid protein of an AAV5 serotype.

356. The AAV variant of claim 354, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one SEQ ID NO: 28 to SEQ ID NO: 32.

20 357. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

358. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

25 359. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

360. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

5 361. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

362. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

10 363. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

364. The AAV variant of claim 173, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

365. The AAV variant of any one of claims 359, 361, and 363, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 12 to SEQ ID NO: 18.

20 366. The AAV variant of any one of claims 360, 362, and 364, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 86 to SEQ ID NO: 89.

367. The AAV variant of any one of claims 360, 362, and 364, wherein the peptide comprises the sequence of SEQ ID NO: 89.

25 368. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.

369. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.

370. The AAV vector of claim 369, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 68 to SEQ ID NO: 75.

5 371. The AAV vector of claim 369, wherein the peptide comprises the amino acid sequence SEQ ID NO: 71.

372. The AAV vector of claim 368, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

10 373. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

374. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

15 375. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

20 376. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

377. The AAV vector of any one of claims 373 and 375, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 19 to SEQ ID NO: 27.

25 378. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

379. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

380. The AAV vector of claim 379, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 90 to SEQ ID NO: 110.

5 381. The AAV vector of claims 379, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

382. The AAV vector of claims 378, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 4-7.

10 383. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

384. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of
15 the capsid protein of an AAV3B serotype.

385. The AAV vector of claim 384, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

20 386. The AAV vector of claim 383, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 8 to SEQ ID NO: 11.

387. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

25 388. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

389. The AAV vector of claim 387, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one SEQ ID NO: 28 to SEQ ID NO: 32.

5 390. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

391. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

10 392. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

15 393. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

394. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

20 395. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

396. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

25 397. The AAV vector of claim 247, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

398. ~~The AAV vector of any one of claims 392, 394, and 396, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 12 to SEQ ID NO: 18.~~

5 399. ~~The AAV vector of any one of claims 393, 395, and 397, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 86 to SEQ ID NO: 89.~~

400. ~~The AAV vector of any one of claims 393, 395, and 397, wherein the peptide comprises the sequence of SEQ ID NO: 89.~~

401. A capsid protein comprising an inserted peptide, wherein the peptide is inserted at

10 ~~—— (i) amino acid position 590 of an AAV1 capsid protein,~~

~~—— (ii) amino acid position 454 or 590 of an AAV6 capsid protein,~~

~~—— (iii) amino acid position 588 of an AAV2 capsid protein,~~

~~—— (iv) amino acid position 589 of an AAV3B capsid protein,~~

~~—— (v) amino acid position 578 of an AAV5 capsid protein,~~

15 ~~—— (vi) amino acid position 591 of the an AAV8 capsid protein, or~~

~~—— (vi) amino acid position 266, 455, or 589 of an AAV9 capsid protein,~~

~~—— wherein the positions correspond to the numbering of VP1 in the AAV serotype.~~

20 402. ~~The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.~~

403. ~~The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV1 serotype.~~

404. The capsid protein of claim 403, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 68 to SEQ ID NO: 75.

5 405. The capsid protein of claim 403, wherein the peptide comprises the amino acid sequence SEQ ID NO: 71.

406. The capsid protein of claim 402, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 1, SEQ ID NO: 2 and SEQ ID NO: 3.

10 407. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

408. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 454 of the capsid protein of an AAV6 serotype.

15 409. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

20 410. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 590 of the capsid protein of an AAV6 serotype.

411. The capsid protein of any one of claims 407 and 409, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 19 to SEQ ID NO: 27.

25 412. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

413. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 588 of the capsid protein of an AAV2 serotype.

414. The capsid protein of claim 413, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 90 to SEQ ID NO: 110.

5 415. The capsid protein of claims 413, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 95, SEQ ID NO: 94, SEQ ID NO: 96, SEQ ID NO: 101, SEQ ID NO: 103, SEQ ID NO: 106, SEQ ID NO: 91 and SEQ ID NO: 102.

416. The capsid protein of claims 412, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 4-7.

10 417. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

15 418. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV3B serotype.

419. The capsid protein of claim 418, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 78, SEQ ID NO: 80, SEQ ID NO: 77, SEQ ID NO: 79, SEQ ID NO: 76 and SEQ ID NO: 83.

20 420. The capsid protein of claim 417, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 8 to SEQ ID NO: 11.

421. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

25 422. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 578 of the capsid protein of an AAV5 serotype.

423. The capsid protein of claim 421, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one SEQ ID NO: 28 to SEQ ID NO: 32.

5 424. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of SEQ ID NO: 1-32 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

425. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 591 of the capsid protein of an AAV8 serotype.

10 426. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

15 427. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 266 of the capsid protein of an AAV9 serotype.

428. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

20 429. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 455 of the capsid protein of an AAV9 serotype.

430. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 1-32 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

25 431. The capsid protein of claim 401, wherein a peptide comprising the amino acid sequence of any one of SEQ ID NO: 68-110 is inserted at amino acid position 589 of the capsid protein of an AAV9 serotype.

~~432. The capsid protein of any one of claims 426, 428, and 430, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 12 to SEQ ID NO: 18.~~

5 ~~433. The capsid protein of any one of claims 427, 429, and 431, wherein the peptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NO: 86 to SEQ ID NO: 89.~~

~~434. The capsid protein of any one of claims 427, 429, and 431, wherein the peptide comprises the sequence of SEQ ID NO: 89.~~

10 ~~435. A nucleic acid molecule encoding the capsid protein of any one of claims 401 to 434.~~