We claim:

1. An adeno-associated virus (AAV) capsid variant comprising an amino acid sequence at least 95% identical to the amino acid sequence of SEQ ID NO: 739, wherein the AAV capsid variant comprises the amino acid sequence of YPAEVVQK (SEQ ID NO: 943) in variable region VIII (VR-VIII).

2. The AAV capsid variant of claim 1, wherein the amino acid Y is present at position 577, and the amino acid sequence of PAEVVQK (SEQ ID NO: 20) is present at positions 578-584, numbered relative to SEQ ID NO: 982.

3. The AAV capsid variant of claim 1 or 2, wherein VR-VIII comprises positions 571-599, numbered according to SEQ ID NO: 982.

4. An adeno-associated virus (AAV) capsid variant, comprising an amino acid sequence having the following formula: [N2]-[N3], wherein:

(i) [N2] comprises positions X1, X2, X3, X4, and X5, wherein:

(a) position X1 is Y, N, or C;

(b) position X2 is P, K, T, or Q;

(c) position X3 is A or P;

(d) position X4 is E, S, or A; and

(e) position X5 is V, L, or E; and

(ii) [N3] comprises the amino acid sequence of VQK, EQK, VKK, VHK, VQQ, or LQK; and

wherein the AAV capsid variant comprises the amino acid sequence of SEQ ID NO: 739, or an amino acid sequence at least 95% identical thereto.

5. The AAV capsid variant of claim 4, wherein:

(i) [N2] comprises the amino acid sequence of YPAEV (SEQ ID NO: 1), YPPSL (SEQ ID NO: 2), NKAEV (SEQ ID NO: 3), YTAEV (SEQ ID NO: 4), YPAEE (SEQ ID NO: 5), YQAEV (SEQ ID NO: 6), YTPSL (SEQ ID NO: 7), YPAAV (SEQ ID NO: 8), NPAEV (SEQ ID NO: 9), CPAEV (SEQ ID NO: 10), or YQAEE (SEQ ID NO: 11); and/or

(ii) [N2]-[N3] comprises the amino acid sequence of YPAEVVQK (SEQ ID NO: 943), YPPSLVQK (SEQ ID NO: 946), NKAEVVQK (SEQ ID NO: 947), YTAEVVQK (SEQ ID NO: 948), YPAEVEQK (SEQ ID NO: 949), YPAEEVQK (SEQ ID NO: 950), YQAEVVQK (SEQ ID NO: 951), YTPSLVQK (SEQ ID NO: 952), YPPSLEQK (SEQ ID NO: 953), YPPSLVKK (SEQ ID NO: 954), YPAEVVKK (SEQ ID NO: 955), YPAEVVHK (SEQ ID NO: 956), YPAAVVQK (SEQ ID NO: 957),

NPAEVVQK (SEQ ID NO: 958), YPAEVVQQ (SEQ ID NO: 959), CPAEVVQK (SEQ ID NO: 960), YTAEVVKK (SEQ ID NO: 961), YPAEVLQK (SEQ ID NO: 962), or YQAEEVQK (SEQ ID NO: 963).

6. The AAV capsid variant of claim 4 or 5, which further comprises:

(i) [N1], wherein [N1] comprises positions X_D, X_E, and X_F, wherein:

(a) position X_D is Q, T, S, A, I, L, or H;

(b) position X_E is S, G, A, or R; and

(c) position X_F is S, K, L, R, A, or T;

(ii) [N0], wherein [N0] comprises positions X_A, X_B, and X_C, wherein:

(a) position X_A is T, I, or N;

(b) position X_B is N; and

(c) position X_C is N, T, S, or K; and/or

(iii) [N4], wherein [N4] comprises positions X_G and X_H, wherein:

(a) position X_G is T, P, or N; and

(b) position X_H is A.

7. The AAV capsid variant of claim 6, wherein:

(i) [N1] comprises the amino acid sequence of QSS, QSK, TSL, SSS, QSR, AGA, IGS, QAS, ASS, LGS, QST, HSS, LSS, or QRS;

(ii) [N0] comprises the amino acid sequence of TNN, TNT, INN, TNS, NNN, or TNK; and/or

(iii) [N4] comprises the amino acid sequence of TA, PA, or NA.

8. The AAV capsid variant of claim 6 or 7, wherein:

(i) [N1]-[N2] comprises the amino acid sequence of QSSYPAEV (SEQ ID NO: 96), QSKYPAEV (SEQ ID NO: 97), TSLYPAEV (SEQ ID NO: 98), SSSYPAEV (SEQ ID NO: 99), QSRYPAEV (SEQ ID NO: 100), QSSYPPSL (SEQ ID NO: 101), AGAYPAEV (SEQ ID NO: 102), IGSYPAEV (SEQ ID NO: 103), QASYPAEV (SEQ ID NO: 104), ASSYPAEV (SEQ ID NO: 105), LGSYPAEV (SEQ ID NO: 106), QSTNKAEV (SEQ ID NO: 107), HSSYPAEV (SEQ ID NO: 108), SSSYTAEV (SEQ ID NO: 109), TSLYPAEE (SEQ ID NO: 110), ASSYQAEV (SEQ ID NO: 111), QSSYTPSL (SEQ ID NO: 112), QSRYPAEE (SEQ ID NO: 113), LSSYQAEV (SEQ ID NO: 114), HSSYPAAV (SEQ ID NO: 115), QSSNPAEV (SEQ ID NO: 116), QSSYTAEV (SEQ ID NO: 117), TSLCPAEV (SEQ ID NO: 118), QRSYTAEV (SEQ ID NO: 119), or QSSYQAEE (SEQ ID NO: 120);

(ii) [N1]-[N2]-[N3] comprises the amino acid sequence of QSSYPAEVVQK (SEQ ID NO: 150), QSKYPAEVVQK (SEQ ID NO: 151), TSLYPAEVVQK (SEQ ID NO: 152), SSSYPAEVVQK (SEQ ID

NO: 153), QSRYPAEVVQK (SEQ ID NO: 154), QSSYPPSLVQK (SEQ ID NO: 155), AGAYPAEVVQK (SEQ ID NO: 156), IGSYPAEVVQK (SEQ ID NO: 157), QASYPAEVVQK (SEQ ID NO: 158), ASSYPAEVVQK (SEQ ID NO: 159), LGSYPAEVVQK (SEQ ID NO: 160), QSTNKAEVVQK (SEQ ID NO: 161), HSSYPAEVVQK (SEQ ID NO: 162), SSSYTAEVVQK (SEQ ID NO: 163), QSKYPAEVEQK (SEQ ID NO: 164), TSLYPAEEVQK (SEQ ID NO: 165), ASSYQAEVVQK (SEQ ID NO: 166), QSSYTPSLVQK (SEQ ID NO: 167), QSRYPAEEVQK (SEQ ID NO: 168), QSSYPPSLEQK (SEQ ID NO: 169), QSSYPPSLVKK (SEQ ID NO: 170), LSSYQAEVVQK (SEQ ID NO: 171), SSSYPAEVVKK (SEQ ID NO: 172), QSKYPAEVVHK (SEQ ID NO: 173), HSSYPAAVVQK (SEQ ID NO: 174), QSSNPAEVVQK (SEQ ID NO: 175), SSSYPAEVVQQ (SEQ ID NO: 176), QSSYTAEVVQK (SEQ ID NO: 177), TSLCPAEVVQK (SEQ ID NO: 178), QRSYTAEVVQK (SEQ ID NO: 179), QSSYTAEVVKK (SEQ ID NO: 180), HSSYPAEVLQK (SEQ ID NO: 181), or QSSYQAEEVQK (SEQ ID NO: 182);

(iii) [N0]-[N1] comprises the amino acid sequence of TNNQSS (SEQ ID NO: 183), TNNQSK (SEQ ID NO: 184), TNNTSL (SEQ ID NO: 185), TNNSSS (SEQ ID NO: 186), TNNQSR (SEQ ID NO: 187), TNNAGA (SEQ ID NO: 188), TNNIGS (SEQ ID NO: 189), TNNQAS (SEQ ID NO: 190), TNTASS (SEQ ID NO: 191), TNNLGS (SEQ ID NO: 192), TNNQST (SEQ ID NO: 193), TNNHSS (SEQ ID NO: 194), TNNLSS (SEQ ID NO: 195), INNQSS (SEQ ID NO: 196), TNSQSS (SEQ ID NO: 197), NNNQSR (SEQ ID NO: 198), TNSTSL (SEQ ID NO: 199), TNNQRS (SEQ ID NO: 200), or TNKQAS (SEQ ID NO: 201);

(iv) [N0]-[N1]-[N2]-[N3] comprises the amino acid sequence of TNNQSSYPAEVVQK (SEQ ID NO: 500), TNNQSKYPAEVVQK (SEQ ID NO: 503), TNNTSLYPAEVVQK (SEQ ID NO: 506), TNNSSSYPAEVVQK (SEQ ID NO: 508), TNNQSRYPAEVVQK (SEQ ID NO: 510), TNNQSSYPPSLVQK (SEQ ID NO: 512), TNNAGAYPAEVVQK (SEQ ID NO: 513), TNNIGSYPAEVVQK (SEQ ID NO: 514), TNNQASYPAEVVQK (SEQ ID NO: 517), TNTASSYPAEVVQK (SEQ ID NO: 520), TNNLGSYPAEVVQK (SEQ ID NO: 523), TNNQSTNKAEVVQK (SEQ ID NO: 524), TNNHSSYPAEVVQK (SEQ ID NO: 525), TNNSSSYTAEVVQK (SEQ ID NO: 526), TNNQSKYPAEVEQK (SEQ ID NO: 529), TNNTSLYPAEEVQK (SEQ ID NO: 530), TNTASSYQAEVVQK (SEQ ID NO: 531), TNNQSSYTPSLVQK (SEQ ID NO: 533), TNNQSRYPAEEVQK (SEQ ID NO: 534), TNNQSSYPPSLEQK (SEQ ID NO: 535), TNNQSSYPPSLVKK (SEQ ID NO: 536), TNNLSSYQAEVVQK (SEQ ID NO: 539), TNNSSSYPAEVVKK (SEQ ID NO: 540), TNNQSKYPAEVVHK (SEQ ID NO: 542), INNQSSYPAEVVQK (SEQ ID NO: 543), TNNHSSYPAAVVQK (SEQ ID NO: 545), TNSQSSNPAEVVQK (SEQ ID NO: 548), TNNSSSYPAEVVQQ (SEQ ID NO: 551), NNNQSRYPAEVVQK (SEQ ID NO: 552),

TNNQSSYTAEVVQK (SEQ ID NO: 553), TNNTSLCPAEVVQK (SEQ ID NO: 554), TNSTSLYPAEVVQK (SEQ ID NO: 556), TNNQRSYTAEVVQK (SEQ ID NO: 557), TNNQSSYTAEVVKK (SEQ ID NO: 558), TNNHSSYPAEVLQK (SEQ ID NO: 560), TNNQSSYQAEEVQK (SEQ ID NO: 562), or TNKQASYPAEVVQK (SEQ ID NO: 563);

(v) [N3]-[N4] comprises the amino acid sequence of VQKTA (SEQ ID NO: 564), EQKTA (SEQ ID NO: 565), VKKTA (SEQ ID NO: 566), VQKPA (SEQ ID NO: 567), VHKTA (SEQ ID NO: 568), VQQTA (SEQ ID NO: 569), VQKNA (SEQ ID NO: 570), or LQKTA (SEQ ID NO: 571); and/or

(vi) [N0]-[N1]-[N2]-[N3]-[N4] comprises the amino acid sequence of TNNQSSYPAEVVQKTA (SEQ ID NO: 1533), TNNQSKYPAEVVQKTA (SEQ ID NO: 1538), TNNTSLYPAEVVQKTA (SEQ ID NO: 1232), TNNSSSYPAEVVQKTA (SEQ ID NO: 1539), TNNQSRYPAEVVQKTA (SEQ ID NO: 1327), TNNQSSYPPSLVQKTA (SEQ ID NO: 1300), TNNAGAYPAEVVQKTA (SEQ ID NO: 1021), TNNIGSYPAEVVQKTA (SEQ ID NO: 1112), TNNQASYPAEVVQKTA (SEQ ID NO: 1194), TNTASSYPAEVVQKTA (SEQ ID NO: 1575), TNNLGSYPAEVVQKTA (SEQ ID NO: 1027), TNNQSTNKAEVVQKTA (SEQ ID NO: 1578), TNNHSSYPAEVVQKTA (SEQ ID NO: 1310), TNNSSSYTAEVVQKTA (SEQ ID NO: 1214), TNNQSKYPAEVEQKTA (SEQ ID NO: 1254), TNNTSLYPAEEVQKTA (SEQ ID NO: 1583), TNTASSYQAEVVQKTA (SEQ ID NO: 1584), TNNQSSYTPSLVQKTA (SEQ ID NO: 1585), TNNQSRYPAEEVQKTA (SEQ ID NO: 1342), TNNQSSYPPSLEQKTA (SEQ ID NO: 1590), TNNQSSYPPSLVKKTA (SEQ ID NO: 1591), TNNLSSYQAEVVQKTA (SEQ ID NO: 1592), TNNQSSYPPSLVQKPA (SEQ ID NO: 1593), TNNSSSYPAEVVKKTA (SEQ ID NO: 1331), TNNQSKYPAEVVHKTA (SEQ ID NO: 1453), TNNSSSYPAEVVQKPA (SEQ ID NO: 1142), INNQSSYPAEVVQKTA (SEQ ID NO: 1024), TNNHSSYPAAVVQKTA (SEQ ID NO: 1598), TNSQSSNPAEVVQKTA (SEQ ID NO: 1599), TNNSSSYPAEVVQQTA (SEQ ID NO: 1419), NNNQSRYPAEVVQKTA (SEQ ID NO: 1601), TNNQSSYTAEVVQKNA (SEQ ID NO: 1602), TNNTSLCPAEVVQKTA (SEQ ID NO: 1603), TNSTSLYPAEVVQKTA (SEQ ID NO: 1605), TNNQRSYTAEVVQKTA (SEQ ID NO: 1604), TNNQSSYTAEVVKKTA (SEQ ID NO: 1606), TNNHSSYPAEVLQKTA (SEQ ID NO: 1607), TNNQSSYQAEEVQKTA (SEQ ID NO: 1608), or TNKQASYPAEVVQKTA (SEQ ID NO: 1587).

9. The AAV capsid variant of any one of claims 6-8, wherein:

(i) [N2]-[N3] is present in variable region VIII (VR-VIII), wherein VR-VIII comprises positions 571-599, numbered according to SEQ ID NO: 982;

(ii) [N0], [N1], and [N4] are present in VR-VIII, wherein VR-VIII comprises positions 571-599, numbered according to SEQ ID NO: 982;

(iii) X_A of [N0] is present at position 571, X_B of [N0] is present at position 572, and X_C of [N0] is present at position 573, numbered according to SEQ ID NO: 982;

(iv) X_D of [N1] is present at position 574, X_E of [N1] is present at position 575, and X_F of [N1] is present at position 576, numbered according to SEQ ID NO: 982;

(v) X1 of [N2] is present at position 577, X2 of [N2] is present at position 578, X3 of [N2] is present at position 579, X4 of [N2] is present at position 580, and X5 of [N2] is present at position 581, numbered according to SEQ ID NO: 982;

(vi) [N3] is present at positions 582-584, numbered according to SEQ ID NO: 982; and/or

(vii) X_G of [N4] is present at position 585 and X_H of [N4] is present at position 586, numbered according to SEQ ID NO: 982.

10. An adeno-associated virus (AAV) capsid variant comprising:

(a) the amino acid sequence of any one of the sequences provided in Tables 1, 2A, 2B, 9, or 15-20;

(b) an amino acid sequence comprising at least 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15 consecutive amino acids from any one of the sequences provided in Tables 1, 2A, 2B, 9, or 15-20; or

(c) an amino acid sequence comprising one, two, or three but no more than four different amino acids, relative to the amino acid sequence of any one of the amino acid sequences provided in Tables 1, 2A, 2B, 9, or 15-20.

11. The AAV capsid variant of claim 10, wherein:

(i) the at least 3 consecutive amino acids comprise YPA;

(ii) the at least 4 consecutive amino acids comprise YPAE (SEQ ID NO: 21);

(iii) the at least 5 consecutive amino acids comprise YPAEV (SEQ ID NO: 1);

(iv) the at least 6 consecutive amino acids comprise YPAEVV (SEQ ID NO: 725);

(v) the at least 7 consecutive amino acids comprise YPAEVVQ (SEQ ID NO: 726); and/or

(vi) the amino acid sequence comprises YPAEVVQK (SEQ ID NO: 943).

12. The AAV capsid variant of claim 10 or 11, wherein:

(i) the AAV capsid variant comprises the amino acid sequence YPAEVVQK (SEQ ID NO: 943), or an amino acid sequence comprising one, two, or three but no more than four different amino acids relative to the amino acid sequence of YPAEVVQK (SEQ ID NO: 943);

(ii) the AAV capsid variant comprises an amino acid sequence encoded by the nucleotide sequence of SEQ ID NO: 944; or a nucleotide sequence comprising at least one, two, three, four, five, six,

or seven, but no more than ten different nucleotides relative to the nucleotide sequence of SEQ ID NO: 944;

(iii) the nucleotide sequence encoding the AAV capsid variant comprises the nucleotide sequence of SEQ ID NO: 944; or a nucleotide sequence comprising at least one, two, three, four, five, six, or seven, but no more than ten different nucleotides relative to the nucleotide sequence of SEQ ID NO: 944; and/or

(iv) the amino acid Y is present at position 577, and the amino acid sequence of PAEVVQK (SEQ ID NO: 20) is present at positions 578-584, numbered relative to SEQ ID NO: 982.

13. The AAV capsid variant of any one of claims 1-12, which comprises:

(i) an amino acid sequence at least 98% identical to SEQ ID NO: 739;

(ii) an amino acid sequence at least 95% or at least 98% identical to SEQ ID NO: 738; and/or

(iii) an amino acid sequence at least 95% or at least 98% identical to SEQ ID NO: 982.

14. The AAV capsid variant of any one of claims 1-13, which comprises:

(i) the amino acid sequence of SEQ ID NO: 739;

(ii) the amino acid sequence of SEQ ID NO: 738; and/or

(iii) the amino acid sequence of SEQ ID NO: 982.

15. An adeno-associated virus (AAV) capsid variant comprising:

(i) the amino acid sequence of SEQ ID NO: 739;

(ii) the amino acid sequence of SEQ ID NO: 738; and/or

(iii) the amino acid sequence of SEQ ID NO: 982.

16. The AAV capsid variant of any one of claims 1-15, wherein the AAV capsid variant has an increased tropism for a brain cell or a brain tissue, relative to an AAV capsid protein comprising the amino acid sequence of SEQ ID NO: 138.

17. A polynucleotide encoding the AAV capsid variant of any one of claims 1-16.

18. The polynucleotide of claim 17, which comprises the nucleotide sequence of SEQ ID NO: 984, or a nucleotide sequence at least 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical thereto.

19. A peptide comprising:

(a) the amino acid sequence of any one of the sequences provided in Tables 1, 2A, 2B, 9, or 15-20;

(b) an amino acid sequence comprising at least 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15 consecutive amino acids from any one of the sequences provided in Tables 1, 2A, 2B, 9, or 15-20; or

(c) an amino acid sequence comprising one, two, or three but no more than four different amino acids, relative to the amino acid sequence of any one of the amino acid sequences provided in Tables 1, 2A, 2B, 9, or 15-20.

20. An AAV particle comprising the AAV capsid variant of any one of claims 1-16, an AAV capsid variant encoded by the polynucleotide of claim 17 or 18, or an AAV capsid variant comprising the peptide of claim 19.

21. The AAV particle of claim 20, which comprises a nucleotide sequence encoding a payload, wherein the encoded payload comprises a protein, an antibody, an enzyme, a component of a gene editing system, or an inhibitory RNA.

22. The AAV particle of claim 21, which further comprises:

(i) a 5' inverted terminal repeat (ITR) and/or a 3' ITR;

(ii) a promoter operably linked to the nucleotide sequence encoding the payload;

(iii) an enhancer;

(iv) a Kozak sequence;

(v) an intron;

(vi) an exon;

(vii) a nucleotide sequence encoding a microRNA (miR) binding site; and/or

(viii) a polyadenylation (polyA) sequence.

23. A vector comprising a polynucleotide encoding the AAV capsid variant of any one of claims 1-16, the polynucleotide of claim 17 or 18, or a polynucleotide encoding the peptide of claim 19.

24. A cell comprising the AAV capsid variant of any one of claims 1-16, the polynucleotide of claim 17 or 18, a polynucleotide encoding the peptide of claim 19, the AAV particle of any one of claims 20-22, or the vector of claim 23, optionally wherein:

(i) the cell is a mammalian cell or an insect cell;

(ii) the cell is a cell of a brain region or a spinal cord region; and/or

(iii) the cell is a neuron, a sensory neuron, a motor neuron, an astrocyte, a glial cell, an oligodendrocyte, or a muscle cell.

25. A method of making an AAV particle, comprising:

(i) providing a host cell comprising a viral genome and the AAV capsid variant of any one of claims 1-16; and

(ii) incubating the host cell under conditions suitable to enclose the viral genome in the AAV capsid variant;

thereby making the AAV particle.

26. A pharmaceutical composition comprising the AAV particle of any one of claims 20-22, an AAV particle comprising the AAV capsid variant of any one of claims 1-16, or an AAV particle comprising the peptide of claim 19, and a pharmaceutically acceptable excipient.

27. The AAV particle of any one of claims 20-22, an AAV particle comprising the AAV capsid variant of any one of claims 1-16, an AAV particle comprising the peptide of claim 19, or the pharmaceutical composition of claim 26, for use in delivering a payload to a cell or tissue.

28. The AAV particle or the pharmaceutical composition for use of claim 27, wherein the cell is:

(i) a cell of a brain region or a spinal cord region, optionally a cell of the temporal cortex, perirhinal cortex, globus pallidus, putamen, caudate, thalamus, hippocampus, geniculate nucleus, Purkinje Layer, deep cerebellar nuclei, cerebellum, cervical spinal cord region, thoracic spinal cord region, lumbar spinal cord region, or a combination thereof;

(ii) a cell of the heart;

(iii) a cell of the muscle;

(iv) a neuron, a sensory neuron, a motor neuron, an astrocyte, a glial cell, or an oligodendrocyte; and/or

(v) within a subject, wherein the subject has, has been diagnosed with having, or is at risk of having a genetic disorder, a neurological disorder, a neurodegenerative disorder, a neuro-oncological disorder, a muscular disorder, or a neuromuscular disorder.

29. The AAV particle or the pharmaceutical composition for use of claim 28, wherein the genetic disorder, neurological disorder, neurodegenerative disorder, muscular disorder, neuromuscular disorder, or neuro-oncological disorder is Huntington’s Disease, Amyotrophic Lateral Sclerosis (ALS), Gaucher

Disease, Dementia with Lewy Bodies, Parkinson's disease, Spinal Muscular Atrophy, Alzheimer's Disease, a leukodystrophy, Alexander disease, autosomal dominant leukodystrophy with autonomic diseases (ADLD), Canavan disease, cerebrotendinous xanthomatosis (CTX), metachromatic leukodystrophy (MLD), Pelizaeus-Merzbacher disease, Refsum disease, a cancer, a HER2/neu positive cancer, or a glioblastoma.

30. The AAV particle or the pharmaceutical composition for use of any one of claims 27-29, wherein the AAV particle or the pharmaceutical composition is formulated for intravenous administration, intra-cisterna magna injection (ICM), intracerebral administration, intrathecal administration, intracerebroventricular administration, intraparenchymal administration, or intramuscular administration.

31. Use of the AAV particle of any one of claims 20-22, an AAV particle comprising the AAV capsid variant of any one of claims 1-16, an AAV particle comprising the peptide of claim 19, or the pharmaceutical composition of claim 26, in the manufacture of a medicament for delivering a payload to a cell or tissue.

32. The use of claim 31, wherein the cell is:

(i) a cell of a brain region or a spinal cord region, optionally a cell of the temporal cortex, perirhinal cortex, globus pallidus, putamen, caudate, thalamus, hippocampus, geniculate nucleus, Purkinje Layer, deep cerebellar nuclei, cerebellum, cervical spinal cord region, thoracic spinal cord region, lumbar spinal cord region, or a combination thereof;

(ii) a cell of the heart;

(iii) a cell of the muscle;

(iv) a neuron, a sensory neuron, a motor neuron, an astrocyte, a glial cell, or an oligodendrocyte; and/or

(v) within a subject, wherein the subject has, has been diagnosed with having, or is at risk of having a genetic disorder, a neurological disorder, a neurodegenerative disorder, a muscular disorder, a neuromuscular disorder, or a neuro-oncological disorder.

33. The use of claim 32, wherein the genetic disorder, neurological disorder, neurodegenerative disorder, muscular disorder, neuromuscular disorder, or neuro-oncological disorder is Huntington's Disease, Amyotrophic Lateral Sclerosis (ALS), Gaucher Disease, Dementia with Lewy Bodies, Parkinson's disease, Spinal Muscular Atrophy, Alzheimer's Disease, a leukodystrophy, Alexander disease, autosomal dominant leukodystrophy with autonomic diseases (ADLD), Canavan disease, cerebrotendinous

xanthomatosis (CTX), metachromatic leukodystrophy (MLD), Pelizaeus-Merzbacher disease, Refsum disease, a cancer, a HER2/neu positive cancer, or a glioblastoma.

34. The use of any one of claims 31-33, wherein the AAV particle or the pharmaceutical composition is formulated for intravenous administration, intra-cisterna magna injection (ICM), intracerebral administration, intrathecal administration, intracerebroventricular administration, intraparenchymal administration, or intramuscular administration.

35. The AAV particle of any one of claims 20-22, an AAV particle comprising the AAV capsid variant of any one of claims 1-16, an AAV particle comprising the peptide of claim 19, or the pharmaceutical composition of claim 26, for use in treating a subject having or diagnosed with having a genetic disorder, a neurological disorder, a neurodegenerative disorder, a muscular disorder, a neuromuscular disorder, or a neuro-oncological disorder.

36. The AAV particle or the pharmaceutical composition for use of claim 35, wherein:

(i) the genetic disorder, neurological disorder, neurodegenerative disorder, muscular disorder, neuromuscular disorder, or neuro-oncological disorder is Huntington's Disease, Amyotrophic Lateral Sclerosis (ALS), Gaucher Disease, Dementia with Lewy Bodies, Parkinson's disease, Spinal Muscular Atrophy, Alzheimer's Disease, a leukodystrophy, Alexander disease, autosomal dominant leukodystrophy with autonomic diseases (ADLD), Canavan disease, cerebrotendinous xanthomatosis (CTX), metachromatic leukodystrophy (MLD), Pelizaeus-Merzbacher disease, Refsum disease, a cancer, a HER2/neu positive cancer, or a glioblastoma; and/or

(ii) the AAV particle or the pharmaceutical composition is formulated for intravenous administration, intramuscular administration, intracerebral administration, intrathecal administration, intracerebroventricular administration, intraparenchymal administration, or intra-cisterna magna injection (ICM).

37. Use of the AAV particle of any one of claims 20-22, an AAV particle comprising the AAV capsid variant of any one of claims 1-16, an AAV particle comprising the peptide of claim 19, or the pharmaceutical composition of claim 26, in the manufacture of a medicament for treating a subject having or diagnosed with having a genetic disorder, a neurological disorder, a neurodegenerative disorder, a muscular disorder, a neuromuscular disorder, or a neuro-oncological disorder.

38. The use of claim 37, wherein:

(i) the genetic disorder, neurological disorder, neurodegenerative disorder, muscular disorder, neuromuscular disorder, or neuro-oncological disorder is Huntington's Disease, Amyotrophic Lateral Sclerosis (ALS), Gaucher Disease, Dementia with Lewy Bodies, Parkinson's disease, Spinal Muscular Atrophy, Alzheimer's Disease, a leukodystrophy, Alexander disease, autosomal dominant leukodystrophy with autonomic diseases (ADLD), Canavan disease, cerebrotendinous xanthomatosis (CTX), metachromatic leukodystrophy (MLD), Pelizaeus-Merzbacher disease, Refsum disease, a cancer, a HER2/neu positive cancer, or a glioblastoma; and/or

(ii) the AAV particle or the pharmaceutical composition is formulated for intravenous administration, intramuscular administration, intracerebral administration, intrathecal administration, intracerebroventricular administration, intraparenchymal administration, or intra-cisterna magna injection (ICM).