CLAIMS

1. A lentiviral vector comprising:

a lipid coat which comprises a plurality of CD47 polypeptides and does not comprise a MHC-I polypeptide; and

a nucleic acid comprising a nucleotide sequence encoding a polypeptide with FVIII activity, wherein the nucleotide sequence has:

(i) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 1;

(ii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 2;

(iii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 70;

(iv) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 71;

(v) at least 95%, at least 96%, at least 97%, at least 98% or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 3;

(vi) at least 95%, at least 96%, at least 97%, at least 98% or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 4;

(vii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 5; or

(viii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 and 2320-4374 of SEQ ID NO: 6;

wherein the lentiviral vector is produced in a host cell that is modified to have increased expression of CD47 relative to an unmodified corresponding cell, and is free of MHC-1.

2. A lentiviral vector comprising:

a lipid coat which comprises a plurality of CD47 polypeptides and does not comprise a MHC-I polypeptide; and

a nucleic acid comprising a nucleotide sequence which comprises a first nucleic acid sequence encoding an N-terminal portion of a Factor VIII (FVIII) polypeptide and a second nucleic acid sequence encoding a C-terminal portion of a FVIII polypeptide;

wherein the first nucleic acid sequence comprises:

(i) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 of SEQ ID NO: 3;

(ii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99%

sequence identity to nucleotides 58-2277 of SEQ ID NO: 4;

(iii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 of SEQ ID NO: 5; or

(iv) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 58-2277 of SEQ ID NO: 6; and

wherein the second nucleic acid sequence comprises:

(i) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 2320-4374 of SEQ ID NO: 3;

(ii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 2320-4374 of SEQ ID NO: 4;

(iii) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 2320-4374 of SEQ ID NO: 5; or

(iv) at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% sequence identity to nucleotides 2320-4374 of SEQ ID NO: 6;

wherein the N-terminal portion and the C-terminal portion together have a FVIII polypeptide activity; and

wherein the lentiviral vector is produced in a host cell that is modified to have increased expression of CD47 relative to an unmodified corresponding cell, and is free of MHC-1.

3. The lentiviral vector of claim 1 or claim 2, wherein the lentiviral vector is for use in treating hemophilia A in a subject in need thereof that comprises the subject in need thereof to be administered at least one dose ranging from $1x10^8$ to $5x10^{10}$ transducing units/kg (TU/kg) of the lentiviral vector.

4. The lentiviral vector for use according to claim 3, wherein:

the dose is about $5x10^{10}$ TU/kg, about $4.5x10^{10}$ TU/kg, about $4x10^{10}$ TU/kg, about $3.5x10^{10}$ TU/kg, about $3x10^{10}$ TU/kg, about $2.5x10^{10}$ TU/kg, about $2x10^{10}$ TU/kg, about $1.5x10^{10}$ TU/kg, about $1x10^{10}$ TU/kg, about $9.5x10^9$ TU/kg, about $9x10^9$ TU/kg, about $8.5x10^9$ TU/kg, about $8x10^9$ TU/kg, about $7.5x10^9$ TU/kg, about $7x10^9$ TU/kg, about $6.5x10^9$ TU/kg, about $6x10^9$ TU/kg, about $5.5x10^9$ TU/kg, about $5x10^9$ TU/kg, about $4.5x10^9$ TU/kg, about $4x10^9$ TU/kg, about $3.5x10^9$ TU/kg, about $3x10^9$ TU/kg, about $2.5x10^9$ TU/kg, about $2x10^9$ TU/kg, about $1.5x10^9$ TU/kg, about $1x10^9$ TU/kg, about $9.5x10^8$ TU/kg, about $9x10^8$ TU/kg, about $8.5x10^8$ TU/kg, about $8x10^8$ TU/kg, about $7.5x10^8$ TU/kg, about $7x10^8$ TU/kg, about $6.5x10^8$ TU/kg, about $6x10^8$ TU/kg, about $5.5x10^8$ TU/kg, about $5x10^8$ TU/kg, about $4.5x10^8$ TU/kg, about $4x10^8$ TU/kg, about $3.5x10^8$ TU/kg, about $3x10^8$ TU/kg, about $2.5x10^8$ TU/kg, about $2x10^8$ TU/kg, about $1.5x10^8$ TU/kg, or about $1x10^8$ TU/kg;

the dose is between $1x10^8$ and $5x10^9$ TU/kg, between $1x10^8$ and $1x10^9$ TU/kg, between $1x10^8$ and $1x10^{10}$ TU/kg, between $1x10^9$ and $5x10^{10}$ TU/kg, between $2x10^9$ and $5x10^{10}$ TU/kg, between $3x10^9$ and $5x10^{10}$ TU/kg, between $4x10^9$ and $5x10^{10}$ TU/kg, between $5x10^9$ and $5x10^{10}$ TU/kg, between $6x10^9$ and $5x10^{10}$ TU/kg, between $7x10^9$ and $5x10^{10}$ TU/kg, $8x10^9$ and $5x10^{10}$ TU/kg, between $9x10^9$ and $5x10^{10}$ TU/kg, between 10^{10} and $5x10^{10}$ TU/kg, between $1.5x10^{10}$ and $5x10^{10}$ TU/kg, between $2x10^{10}$ and $5x10^{10}$ TU/kg, between $2.5x10^{10}$ and $5x10^{10}$ TU/kg, between $3x10^{10}$ and $5x10^{10}$ TU/kg, between $3.5x10^{10}$ and $5x10^{10}$ TU/kg, between $4x10^{10}$ and $5x10^{10}$ TU/kg, or between $4.5x10^{10}$ and $5x10^{10}$ TU/kg;

the dose is between $1x10^9$ and $5x10^{10}$ TU/kg, between $1x10^9$ and $4.5x10^{10}$ TU/kg, between $1x10^9$ and $4x10^{10}$ TU/kg, between $1x10^9$ and $3.5x10^{10}$ TU/kg, between $1x10^9$ and $3x10^{10}$ TU/kg, between $1x10^9$ and $2.5x10^{10}$ TU/kg, between $1x10^9$ and $2x10^{10}$ TU/kg, between $1x10^9$ and $1.5x10^{10}$ TU/kg, between $1x10^9$ and $1x10^{10}$ TU/kg, between $1x10^9$ and $9x10^9$ TU/kg, between $1x10^9$ and $8x10^9$ TU/kg, between $1x10^9$ and $7x10^9$ TU/kg, between $1x10^9$ and $6x10^9$ TU/kg, between $1x10^9$ and $5x10^9$ TU/kg, between $1x10^9$ and $4x10^9$ TU/kg, between $1x10^9$ and $3x10^9$ TU/kg, and between $1x10^9$ and $2x10^9$ TU/kg;

the dose is between $1x10^{10}$ and $2x10^{10}$ TU/kg, between $1.1x10^{10}$ and $1.9x10^{10}$ TU/kg, between $1.2x10^{10}$ and $1.8x10^{10}$ TU/kg, between $1.3x10^{10}$ and $1.7x10^{10}$ TU/kg, or between $1.4x10^{10}$ and $1.6x10^{10}$ TU/kg;

the dose is between $2.5x10^9$ TU/kg and $3.5x10^9$ TU/kg, between $2.6\ x10^9$ TU/kg and $3.4x10^9$ TU/kg, between $2.7x10^9$ TU/kg and $3.3x10^9$ TU/kg, between $2.8x10^9$ TU/kg and $3.2x10^9$ TU/kg, or between $2.9x10^9$ TU/kg and $3.1x10^9$ TU/kg; or

the dose is between $5.5x10^9$ TU/kg and $6.5x10^9$ TU/kg, between $5.6\ x10^9$ TU/kg and $6.4x10^9$ TU/kg, between $5.7x10^9$ TU/kg and $6.3x10^9$ TU/kg, between $5.8x10^9$ TU/kg and $6.2x10^9$ TU/kg, or between $5.9x10^9$ TU/kg and $6.1x10^9$ TU/kg.

5. The lentiviral vector for use according to claim 3, wherein the dose is about $1.5x10^{10}$ TU/kg, about $1.0x10^9$ TU/kg, about $3.0x10^9$ TU/kg, about $6.0x10^9$ TU/kg, about $1x10^8$ TU/kg, about $8.3x10^8$ TU/kg, about $1.5x10^9$ TU/kg, about $4.5x10^9$ TU/kg, or about $1.3x10^{10}$ TU/kg.

6. The lentiviral vector for use according to any one of claims 3-5, wherein upon administration of the lentiviral vector to the subject, plasma FVIII activity in the subject is increased at 24 hours to 48 hours post administration of the lentiviral vector–relative to a subject administered a reference vector comprising a nucleic acid comprising SEQ ID NO: 16; and

optionally wherein the plasma FVIII activity is increased by at least 2-fold, at least 3-fold, at least 4-fold, at least 5-fold, at least 6-fold, at least 7-fold, at least 8-fold, at least 9-fold, at least 10-fold, at least 11-fold, at least 12-fold, at least 13-fold, at least 14-fold, at least 15-

fold, at least 20-fold, at least 25-fold, at least 30-fold, at least 35-fold, at least 40-fold, at least 50-fold, at least 60-fold, at least 70-fold, at least 80-fold, at least 90-fold, at least 100-fold, at least 110-fold, at least 120-fold, at least 130-fold, at least 140-fold, at least 150-fold, at least 160-fold, at least 170-fold, at least 180-fold, at least 190-fold, or at least 200-fold.

7. The lentiviral vector for use according to any one of claims 3 to 6, wherein the lentiviral vector is formulated to be administered to the subject as a single dose or multiple doses.

8. The lentiviral vector for use according to any one of claims 3 to 7, wherein the lentiviral vector is formulated to be administered to the subject via intravenous injection.

9. The lentiviral vector for use according to any one of claims 3 to 8, wherein the subject is an adult subject.

10. The lentiviral vector for use according to any one of claims 3 to 9, wherein the lentiviral vector comprises a tissue specific promoter, optionally wherein the tissue specific promoter selectively enhances expression of the polypeptide with FVIII activity in a target liver cell; and/or wherein the tissue specific promoter selectively enhances expression of the polypeptide with FVIII activity in a target liver cell comprises an mTTR promoter.

11. The lentiviral vector for use according to claim 10, wherein the target liver cell is a hepatocyte, and optionally wherein the nucleic acid is stably integrated into the genome of the hepatocyte.

12. The lentiviral vector for use according to any one of claims 3 to 11, wherein nucleotide sequence encoding a polypeptide with FVIII activity comprises LV-coFVIII-6 (SEQ ID NO:71).

13. The lentiviral vector for use according to any one of claims 3 to 11, wherein the nucleotide sequence encoding a polypeptide with FVIII activity comprises LV-coFVIII-6-XTEN (SEQ ID NO:72).

14. The lentiviral vector for use according to any one of claims 3 to 13, wherein the lentivirus vector is formulated to be administered to the subject in a single dose or in at least two sub-doses.

15. The lentiviral vector for use according to any one of claims 3 to 14, wherein the nucleotide sequence encoding a polypeptide with FVIII activity further comprises a nucleic

acid sequence encoding a signal peptide, wherein the nucleic acid sequence encoding a signal peptide has at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, or 100% sequence identity to:

(i) nucleotides 1 to 57 of SEQ ID NO: 1;
(ii) nucleotides 1 to 57 of SEQ ID NO: 2;
(iii) nucleotides 1 to 57 of SEQ ID NO: 3;
(iv) nucleotides 1 to 57 of SEQ ID NO: 4;
(v) nucleotides 1 to 57 of SEQ ID NO: 5;
(vi) nucleotides 1 to 57 of SEQ ID NO: 6;
(vii) nucleotides 1 to 57 of SEQ ID NO: 70;
(viii) nucleotides 1 to 57 of SEQ ID NO: 71; or
(ix) nucleotides 1 to 57 of SEQ ID NO: 68.

16. The lentiviral vector for use according to any one of claims 3 to 15, wherein the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide comprises one or more properties selected from the group consisting of:

(a) the human codon adaptation index of the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide is increased relative to SEQ ID NO: 16;

(b) the frequency of optimal codons of the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide is increased relative to SEQ ID NO:16;

(c) the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide contains a higher percentage of G/C nucleotides compared to the percentage of G/C nucleotides in SEQ ID NO: 16;

(d) the relative synonymous codon usage of the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence

encoding the C-terminal portion of the FVIII polypeptide is increased relative to SEQ ID NO: 16;

(e) the effective number of codons of the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide is reduced relative SEQ ID NO: 16;

(f) the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide contains fewer MARS/ARS sequences (SEQ ID NOs: 21 and 22) relative to SEQ ID NO: 16;

(g) the nucleotide sequence encoding a polypeptide with FVIII activity, the first nucleic acid sequence encoding the N-terminal portion of the Factor VIII (FVIII) polypeptide, and/or the second nucleic acid sequence encoding the C-terminal portion of the FVIII polypeptide contains fewer destabilizing elements (SEQ ID NOs: 23 and 24) relative to SEQ ID NO: 16; and

(h) any combination thereof.

17. The lentiviral vector for use according to any one of claims 3 to 16, wherein the nucleotide sequence encoding a polypeptide with FVIII activity further comprises a heterologous nucleotide sequence encoding a heterologous amino acid sequence, optionally wherein the heterologous amino acid sequence is an immunoglobulin constant region or a portion thereof, XTEN, transferrin, albumin, or a PAS sequence, and more preferably wherein the heterologous amino acid sequence is linked to the N-terminus or the C-terminus of the amino acid sequence encoded by a nucleotide sequence encoding a polypeptide with FVIII activity or inserted between two amino acids in the amino acid sequence encoded by the nucleotide sequence at one or more insertion sites selected from TABLE below:

Insertion Site	Domain	Insertion Site	Domain	Insertion Site	Domain
3	A1	375	A2	1749	A3
18	A1	378	A2	1796	A3
22	A1	399	A2	1802	A3
26	A1	403	A2	1827	A3
40	A1	409	A2	1861	A3
60	A1	416	A2	1896	A3
65	A1	442	A2	1900	A3
81	A1	487	A2	1904	A3
116	A1	490	A2	1905	A3
119	A1	494	A2	1910	A3
130	A1	500	A2	1937	A3
188	A1	518	A2	2019	A3
211	A1	599	A2	2068	C1
216	A1	603	A2	2111	C1
220	A1	713	A2	2120	C1
224	A1	745	B	2171	C2
230	A1	1656	a3 region	2188	C2
333	A1	1711	A3	2227	C2
336	A1	1720	A3	2332	CT
339	A1	1725	A3		

wherein the insertion sites indicate the amino acid position corresponding to an amino acid position of mature human FVIII (SEQ ID NO: 15).

18. The lentiviral vector for use according to any one of claims 3 to 17, wherein the FVIII polypeptide is a full length FVIII or a B domain deleted FVIII.

19. The lentiviral vector for use according to any one of claims 3 to 18, wherein the CD47 polypeptide is a human CD47 polypeptide.

20. The lentiviral vector for use according to any one of claims 3 to 19, wherein the host cell is a HEK 293T cell modified to have increased expression of CD47 relative to unmodified HEK 293T cells, and is free of MHC-1.