WHAT IS CLAIMED:

1. An arenavirus S segment, wherein the arenavirus S segment is engineered to carry an open reading frame (ORF) encoding a prostate cancer-related antigen or an antigenic fragment thereof, wherein the prostate cancer-related antigen is selected from the group consisting of: prostatic acid phosphatase (PAP), prostate specific antigen (PSA), and prostate-specific membrane antigen (PSMA).

2. The arenavirus S segment of claim 1, wherein the arenavirus S segment is engineered to carry:

(1) a heterologous ORF encoding PAP or an antigenic fragment thereof in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR;

(2) a heterologous ORF encoding PAP or an antigenic fragment thereof in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding GP in a position under control of an arenavirus genomic 5' UTR;

(3) a heterologous ORF encoding PAP or an antigenic fragment thereof in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR; or

(4) a heterologous ORF encoding PAP or an antigenic fragment thereof in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding NP in a position under control of an arenavirus genomic 5' UTR.

3. The arenavirus S segment of claim 1, wherein the arenavirus S segment is engineered to carry:

(1) a heterologous ORF encoding PSA or an antigenic fragment thereof in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR;

(2) a heterologous ORF encoding PSA or an antigenic fragment thereof in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding GP in a position under control of an arenavirus genomic 5' UTR;

(3) heterologous ORF encoding PSA or an antigenic fragment thereof in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR; or

(4) a heterologous ORF encoding PSA or an antigenic fragment thereof in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding NP in a position under control of an arenavirus genomic 5' UTR.

4. The arenavirus S segment of claim 1, wherein the arenavirus S segment is engineered to carry:

(1) a heterologous ORF encoding an antigenic fragment of PSMA in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR;

(2) a heterologous ORF encoding an antigenic fragment of PSMA in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding GP in a position under control of an arenavirus genomic 5' UTR;

(3) a heterologous ORF encoding an antigenic fragment of PSMA in a position under control of an arenavirus genomic 5' UTR, and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR; or

(4) a heterologous ORF encoding an antigenic fragment of PSMA in a position under control of an arenavirus genomic 3' UTR, and an ORF encoding NP in a position under control of an arenavirus genomic 5' UTR.

5. The arenavirus S segment of claim 2, wherein the amino acid sequence of PAP or an antigenic fragment thereof:

(1) comprises at least 80% or 90% identity to the amino acid sequence of SEQ ID NO: 1;

(2) comprises the amino acid sequence of SEQ ID NO: 1;

(3) comprises the amino acid sequence of SEQ ID NO: 18;

(4) consists of the amino acid sequence of SEQ ID NO: 1; or

(5) consists of the amino acid sequence of SEQ ID NO: 18.

6. The arenavirus S segment of claim 3, wherein the amino acid sequence of PSA or an antigenic fragment thereof:

(1) comprises at least 80% or 90% identity to the amino acid sequence of SEQ ID NO: 2;

(2) comprises the amino acid sequence of SEQ ID NO: 2; or

(3) consists of the amino acid sequence of SEQ ID NO: 2.

7. The arenavirus S segment of claim 4, wherein the amino acid sequence of the antigenic fragment of PSMA:

(1) comprises at least 80% or 90% identity to the amino acid sequence of SEQ ID NO: 3 or SEQ ID NO: 4; or

(2) comprises the amino acid sequence of SEQ ID NO: 3 or SEQ ID NO: 4; or

(3) consists of the amino acid sequence of SEQ ID NO: 3 or SEQ ID NO: 4.

8. The arenavirus S segment of claim 2, wherein the nucleotide sequence of the ORF encoding PAP or an antigenic fragment thereof:

(1) comprises at least 50%, 60%, 70%, 80%, or 90% identity to the nucleotide sequence of SEQ ID NO: 5;

(2) comprises the nucleotide sequence of SEQ ID NO: 5; or

(3) consists of the nucleotide sequence of SEQ ID NO: 5.

9. The arenavirus S segment of claim 3, wherein the nucleotide sequence of the ORF encoding PSA or an antigenic fragment thereof:

(1) comprises at least 50%, 60%, 70%, 80%, or 90% identity to the nucleotide sequence of SEQ ID NO: 6;

(2) comprises the nucleotide sequence of SEQ ID NO: 6; or

(3) consists of the nucleotide sequence of SEQ ID NO: 6.

10. The arenavirus S segment of claim 4, wherein the nucleotide sequence of the ORF encoding the antigenic fragment of PSMA:

(1) comprises at least 50%, 60%, 70%, 80%, or 90% identity to SEQ ID NO: 7 or SEQ ID NO: 8;

(2) comprises the nucleotide sequence of SEQ ID NO: 7 or SEQ ID NO: 8; or

(3) consists of the nucleotide sequence of SEQ ID NO: 7 or SEQ ID NO: 8.

11. A cDNA of the arenavirus S segment of any one of claims 1 to 10.

12. A DNA expression vector comprising the cDNA of claim 11.

13. A host cell comprising the arenavirus S segment of any one of claims 1 to 10, the cDNA of claim 11, or the DNA expression vector of claim 12.

14. A tri-segmented arenavirus particle comprising one arenavirus L segment and two arenavirus S segments, wherein the two arenavirus S segments are any one of claims 1 to 10, and wherein one of the two arenavirus S segments comprises GP and the other comprises NP, wherein optionally the tri-segmented arenavirus particle has stable expression of the prostate cancer-related antigen or an antigenic fragment thereof after being passaged at least 4, 5, 6, 7, 8, 9, or 10 generations.

15. A tri-segmented arenavirus particle comprising one arenavirus L segment and two arenavirus S segments,

(1) wherein a first arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 5 in a position under control of an arenavirus genomic 5' UTR and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR, and a second arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 6 in a position under control of an arenavirus genomic 5' UTR and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR;

(2) wherein a first arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 8 in a position under control of an arenavirus genomic 5' UTR

and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR, and a second arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 7 in a position under control of an arenavirus genomic 5' UTR and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR; or

(3) wherein a first arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 7 in a position under control of an arenavirus genomic 5' UTR and an ORF encoding arenaviral nucleoprotein (NP) in a position under control of an arenavirus genomic 3' UTR, and a second arenavirus S segment is engineered to carry a heterologous ORF consisting of SEQ ID NO: 8 in a position under control of an arenavirus genomic 5' UTR and an ORF encoding arenaviral glycoprotein (GP) in a position under control of an arenavirus genomic 3' UTR.

16. The tri-segmented arenavirus particle of claim 15, wherein the tri-segmented arenavirus particle is derived from lymphocytic choriomeningitis virus (LCMV) or Pichinde virus (PICV),

wherein optionally the tri-segmented arenavirus particle is derived from LCMV, wherein optionally said LCMV is MP strain, WE strain, an LCMV clone 13 expressing the glycoprotein of LCMV strain WE instead of the endogenous LCMV clone 13 glycoprotein, Armstrong strain, or Armstrong Clone 13 strain; or

wherein optionally the tri-segmented arenavirus particle is derived from PICV, wherein optionally said PICV is strain Munchique CoAn4763 isolate P18, or P2 strain.

17. A tri-segmented arenavirus particle comprising two S segments,

(1) wherein one of the two S segments comprises SEQ ID NO: 10, and the other one of the two S segments comprises SEQ ID NO: 11;

(2) wherein one of the two S segments comprises SEQ ID NO: 12, and the other one of the two S segments comprises SEQ ID NO: 13;

(3) wherein one of the two S segments comprises SEQ ID NO: 14, and the other one of the two S segments comprises SEQ ID NO: 15; or

(4) wherein one of the two S segments comprises SEQ ID NO: 16, and the other one of the two S segments comprises SEQ ID NO: 17.

18. The tri-segmented arenavirus particle of any one of claims 14 to 17, wherein the tri-segmented arenavirus particle is

(1) infectious and replication competent; and/or

(2) attenuated.

19. A method of generating a tri-segmented arenavirus particle, wherein the method comprises:

(i) transfecting into a host cell the nucleic acids of two arenavirus S segments and one arenavirus L segment, wherein the two arenavirus S segments are any one of claims 1 to 10;

(ii) maintaining the host cell under conditions suitable for virus formation; and

(iii) harvesting the cell culture supernatant containing the tri-segmented arenavirus particle.

20. The method of claim 19, wherein the transcription of the arenavirus L segment and the two arenavirus S segments is performed using a bidirectional expression cassette,

(1) wherein optionally the method further comprises transfecting one or more nucleic acids encoding an arenavirus polymerase into the host cell, wherein optionally the arenavirus polymerase is the arenavirus L protein, and wherein optionally the nucleic acids are encoded in cDNA or RNA,

(2) wherein optionally the method further comprises transfecting one or more nucleic acids encoding the arenavirus NP into the host cell, wherein optionally the nucleic acids are encoded in cDNA or RNA, and/or

(3) wherein optionally transcription of the arenavirus L segment and the two arenavirus S segments are each under the control of a promoter, wherein optionally the promoter is selected from the group consisting of:

(i) a RNA polymerase I promoter;

(ii) a RNA polymerase II promoter; and

(iii) a T7 promoter.

21. A pharmaceutical composition comprising the tri-segmented arenavirus particle of any one of claims 14 to 18, and a pharmaceutically acceptable carrier.

22. A pharmaceutical composition of claim 21 for use as a medicament.

23. Use of the tri-segmented arenavirus particle of any one of claims 14 to 18 for the manufacture of a medicament for the treatment of prostate cancer in a subject in need thereof, wherein the medicament comprises:

a first pharmaceutical composition and a second pharmaceutical composition, wherein the first pharmaceutical composition comprises one or more of the tri-segmented arenavirus particles of any one of claims 14 to 18; and

the second pharmaceutical composition comprises one or more of the tri-segmented arenavirus particles of any one of claims 14 to 18, and

wherein the second pharmaceutical composition is to be administered after a period of time from the administration of the first pharmaceutical composition

24. The use of claim 23, wherein the administration of second pharmaceutical composition after a period of time from the administration of the first pharmaceutical composition is to be repeated.

25. The use of claim 23 or 24, wherein the first and the second pharmaceutical compositions are to be administered intravenously or intratumorally.

26. The use of any one of claims 23 to 25, wherein the one or more tri-segmented arenavirus particles from the first pharmaceutical composition are derived from a different arenavirus species but carry ORF(s) encoding the same prostate cancer-related antigens or antigenic fragments thereof, when compared to the one or more tri-segmented arenavirus particles

from the second pharmaceutical composition, wherein optionally the one or more tri-segmented arenavirus particles from the first pharmaceutical composition are derived from PICV, and the one or more tri-segmented arenavirus particles from the second pharmaceutical composition are derived from LCMV.

27. The use of any one of claims 23 to 26, wherein the one or more tri-segmented arenavirus particle(s) from the first pharmaceutical composition is a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 12, and the other one of the two S segments comprises SEQ ID NO. 13, and the one or more tri-segmented arenavirus particle(s) from the second pharmaceutical composition is a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 10, and the other one of the two S segments comprises SEQ ID NO. 11.

28. The use of any one of claims 23 to 26, wherein

the one or more tri-segmented arenavirus particles from the first pharmaceutical composition are (1) a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 12, and the other one of the two S segments comprises SEQ ID NO. 13 and (2) a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 16, and the other one of the two S segments comprises SEQ ID NO. 17, and

the one or more tri-segmented arenavirus particles from the second pharmaceutical composition are (1) a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 10, and the other one of the two S segments comprises SEQ ID NO. 11 and (2) a tri-segmented arenavirus particle comprising two S segments, wherein one of the two S segments comprises SEQ ID NO. 14, and the other one of the two S segments comprises SEQ ID NO. 15.

29. The use of any one of claims 23 to 28, wherein a second agent is to be administered in combination with the first and/or the second pharmaceutical composition, wherein optionally

(1) the second agent is an agent to treat prostate cancer,

(2) the second agent is selected from the group consisting of docetaxel, mitoxantrone, cabazitaxel, and pembrolizumab,

(3) the second agent is selected from the group consisting of enzalutamide and abiraterone, and/or

(4) the second agent is to be administered with a steroid, wherein optionally the steroid comprises prednisone or methylprednisolone.

30. The use of any one of claims 23 to 29, wherein the first and/or the second pharmaceutical composition and the second agent are to be co-administered simultaneously.

31. The use of any one of claims 23 to 29, wherein

(1) the first and/or the second pharmaceutical composition is to be administered prior to administration of the second agent; or

(2) the first and/or the second pharmaceutical composition is to be administered after administration of the second agent,

wherein optionally the interval between administration of the pharmaceutical composition(s) and the second agent is about 1 hour, about 2 hours, about 3 hours, about 4 hours, about 5 hours, about 6 hours, about 7 hours, about 8 hours, about 9 hours, about 10 hours, about 11 hours, about 12 hours, about 1 day, about 2 days, about 3 days, about 4 days, about 5 days, about 6 days, about 1 week, about 8 days, about 9 days, about 10 days, about 11 days, about 12 days, about 13 days, about 2 weeks, about 3 weeks, about 4 weeks, about 5 weeks, about 6 weeks, about 7 weeks, about 8 weeks, about 9 weeks, about 10 weeks, about 11 weeks, about 12 weeks, about 1 month, about 2 months, about 3 months, about 4 months, about 5 months, about 6 months, or more.

32. The use of any one of claims 23 to 31, wherein the subject is suffering from, is susceptible to, or is at risk for prostate cancer.

33. A kit comprising a container and an instruction for use, wherein the container comprises the tri-segmented arenavirus particle of any one of claims 14 to 18, and wherein

optionally the tri-segmented arenavirus particle is in a pharmaceutical composition suitable for intravenous administration.

34. A kit comprising two or more containers and an instruction for use, wherein one of the containers comprises the tri-segmented arenavirus particle of any one of claims 14 to 18, and another of the containers comprises a second agent, and optionally wherein the tri-segmented arenavirus particle is in a pharmaceutical composition suitable for intravenous administration.

35. The kit of claim 33 or 34, wherein the kit further comprises an apparatus suitable for performing intravenous administration.