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(54) Title: COMPOSITIONS AND METHODS FOR TREATING AND PREVENTING HEPATITIS B AND D

(57) Abstract: Disclosed herein are immunogenic compositions or product combinations of engineered hepatitis B and hepatitis D nucleic acids, genes, peptides, or proteins that can be used to illicit an immune response against a hepatitis B and/or hepatitis D infection. Also disclosed are methods of using the immunogenic compositions or product combinations in subjects to generate immune responses against HBV and/or HDV by administering the compositions or combinations with a nucleic acid prime and polypeptide boost approach.

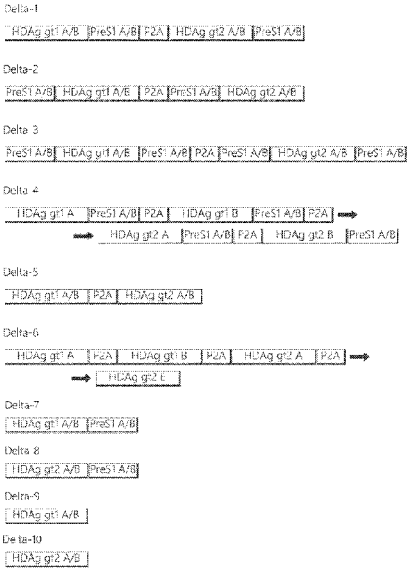


FIGURE 1A

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[Continued on next page]

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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COMPOSITIONS AND METHODS FOR TREATING AND PREVENTING HEPATITIS B AND D

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of U.S. Provisional Patent Application No. 62/966970, filed January 28, 2020, which is hereby expressly incorporated by reference in its entirety.

REFERENCE TO SEQUENCE LISTING

[0002] The present application is being filed along with a Sequence Listing in electronic format. The Sequence Listing is provided as a file entitled SVF005SeqListing.TXT, which was created and last modified on January 26, 2021, which is 141,377 bytes in size. The information in the electronic Sequence Listing is hereby expressly incorporated by reference in its entirety.

FIELD

[0003] Aspects of the present disclosure relate generally to immunogenic compositions or product combinations of engineered hepatitis B (HBV) and hepatitis D (HDV) nucleic acids, genes, peptides, or proteins that can be used to illicit an immune response against an HBV and/or HDV infection. This immune response comprises, consists essentially of, or consists of activated immune cells that produce neutralizing antibodies and activated immune cells, such as T cells and B cells, against HBV and/or HDV. The disclosure also relates generally to methods of using the immunogenic compositions or product combinations in subjects to generate immune responses against HBV and/or HDV by administering the compositions or combinations with a homologous or heterologous nucleic acid and/or polypeptide prime and nucleic acid and/or polypeptide boost approach.

BACKGROUND

[0004] Hepatitis is a disease resulting in swelling and inflammation of the liver. This disorder is commonly caused by viruses, five types of which are currently known (hepatitis A, B, C, D, and E). Hepatitis B infection can be either acute or chronic, with severe chronic

infections causing chronic inflammation, fibrosis, cirrhosis, and hepatocellular carcinoma. The hepatitis B virus has a partially double-stranded circular DNA genome that enters the host nucleus and is transcribed by the host RNA polymerase into four viral mRNA molecules. These are used to translate viral proteins such as capsid proteins and surface antigens as well as produce more DNA genomes using a reverse transcriptase. Hepatitis D is a virusoid that relies on hepatitis B coinfection or superinfection to replicate. The circular single-stranded RNA of hepatitis D is amplified using host RNA polymerases, but also contains a single hepatitis D antigen (HDAg) gene. During hepatitis B and D coinfection or superinfection, intact hepatitis D viruses are packaged with an envelope containing hepatitis B surface antigens surrounding the RNA genome coated with HDAg protein. Incorporation of the hepatitis B surface antigens is essential for hepatitis D infectivity, as hepatitis D does not encode its own receptor binding proteins. Coinfection or superinfection with hepatitis D causes more severe complications, with increased risk of liver failure, cirrhosis, and cancer. There is a present need for effective immunogenic compositions and vaccines to establish prophylactic immunity against both hepatitis B and D infections.

SUMMARY

[0005] The present disclosure relates generally to the use of recombinant nucleic acids, DNA, RNA, proteins, polypeptides, or peptides comprising HBV and/or HDV antigens to induce immune responses, antibody production, immune protection, or immunity against HBV or HDV infections. In some embodiments, the recombinant nucleic acids, DNA, RNA, proteins, polypeptides, or peptides comprising HBV and/or HDV antigens are used in a DNA prime/protein boost composition approach. In some embodiments, this DNA prime/protein boost composition approach results in greater immune response, antibody production, immune protection, or immunity against HBV or HDV infections compared to DNA-only, protein-only, or organism-based immunogenic compositions.

[0006] Chronic hepatitis B and D virus (HBV/HDV) infections can cause cancer. Current HBV therapy using nucleoside analogues (NAs) is life-long and reduces but does not eliminate the risk of cancer. A hallmark of chronic hepatitis B is a dysfunctional HBV-specific T cell response. In some embodiments is an immunotherapy driven by naïve healthy T cells specific for the HDV antigen (HDAg) to bypass the need for HBV-specific T cells in order to

prime PreS1-specific T cells and PreS1 antibodies blocking HBV entry. In some embodiments, combinations of PreS1 and/or HDAg sequences were evaluated for induction of PreS1 antibodies and HBV- and HDV- specific T cells in vitro and in vivo. In some embodiments, neutralization of HBV by PreS1-specific murine and rabbit antibodies was evaluated in cell culture, and rabbit anti-PreS1 were tested for neutralization of HBV in mice repopulated with human hepatocytes. In some embodiments, adoptive transfer of PreS1 antibodies prevented or modulated HBV infection after a subsequent challenge in humanized mice.

[0007] In some embodiments, the nucleic acid or polypeptide compositions comprise sequences, genes, or polypeptides of HBV, HDV, PreS1, or HDAg. In some embodiments, the PreS1 is PreS1 A or PreS1 B. In some embodiments, the HDAg is HDAg genotype 1 strain A (1 A), HDAg genotype 1 strain B (1 B), HDAg genotype 2 strain A (2 A), or HDAg genotype 2 strain B (2 B). In some embodiments, the compositions also comprise an autocatalytic peptide cleavage site. In some embodiments, the autocatalytic peptide cleavage site is a P2A autocatalytic peptide cleavage site. In some embodiments, the PreS1 and HDAg components are grouped together in the compositions. In some embodiments, the PreS1 is downstream or immediately downstream of the HDAg sequence. In some embodiments, the PreS1 and HDAg groups are separated by an autocatalytic peptide cleavage site. In some embodiments, the PreS1 and HDAg groups are separated by a P2A autocatalytic peptide cleavage site.

[0008] In some embodiments, the nucleic acid compositions are a plasmid, virus, bacteriophage, cosmid, fosmid, phagemid, bacterial artificial chromosome (BAC), yeast artificial chromosome (YAC), or human artificial chromosome (HAC). In some embodiments, the nucleic acid compositions are circular or linear. In some embodiments, the nucleic acid compositions are produced in a biological system, including but not limited to mammalian cells, human cells, bacteria cells, *E. coli*, yeast, *S. cerevisiae*, or other appropriate biological system. In some embodiments, the HBV and/or HDV nucleic acids or genes are found in a cassette that comprises elements needed to transcribe and translate the nucleic acids or genes in a biological system.

[0009] In some embodiments, the polypeptide compositions are properly folded or denatured. In some embodiments, the polypeptide compositions are produced in a biological system, including but not limited to mammalian, bacteria, yeast, insect, or cell-free recombinant expression systems. In some embodiments, the polypeptide compositions are

produced in mammalian, human, primary, immortalized, cancer, stem, fibroblasts, human embryonic kidney (HEK) 293, Chinese Hamster Ovary (CHO), bacterial, *Escherichia coli*, yeast, *Saccharomyces cerevisiae*, *Pichia pastoris*, insect, *Spodoptera frugiperda Sf9*, or *S. frugiperda Sf*21 cells, or in a cell-free system. In some embodiments, the polypeptide compositions are purified using techniques known in the art, including but not limited to extraction, freeze-thawing, homogenization, permeabilization, centrifugation, density gradient centrifugation, ultracentrifugation, precipitation, SDS-PAGE, native PAGE, size exclusion chromatography, liquid chromatography, gas chromatography, hydrophobic interaction chromatography, ion exchange chromatography, anion exchange chromatography, cation exchange chromatography, affinity chromatography, immunoaffinity chromatography, metal binding chromatography, nickel column chromatography, epitope tag purification, or lyophilization.

[0010] In some embodiments, the nucleic acid or polypeptide compositions are administered to an animal, including but not limited to humans, mice, rats, rabbits, cats, dogs, horses, cows, pigs, sheep, monkeys, primates, or chickens. In some embodiments, the nucleic acid or polypeptide compositions are administered 1, 2, 3, 4, 5, 6, or 7 days, or 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 weeks, or 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 months or any time within a range defined by any two of the aforementioned times between each dose. In some embodiments, the nucleic acid compositions are administered before the polypeptide compositions are administered. In some embodiments, the polypeptide compositions are administered before the nucleic acid compositions.

[0011] In some embodiments, the nucleic acid or polypeptide compositions are administered in an amount of 1, 10, 100, 1000 ng, or 1, 10, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 μg, or 1, 10, 100, or 1000 mg or any amount within a range defined by any two of the aforementioned amounts. In some embodiments, the nucleic acid or polypeptide compositions are administered with excipients. In some embodiments, the nucleic acid or polypeptide compositions are administered with adjuvants. In some embodiments, the nucleic acid compositions are administered with *in vivo* electroporation.

[0012] In some embodiments, the immunogenicity of the nucleic acid or polypeptide compositions are assessed by measuring interferon gamma (IFNγ) producing immune cells using techniques known in the art, including ELISpot, measuring IgG antibody titer specific to

HBV, HDV, HBV proteins, HBV nucleic acids, HDV proteins, HDV nucleic acids, PreS1, or HDAg, or measuring the neutralization activity of sera or purified antibodies from immunized animals in an *in vitro* or *in vivo* assay.

[0013] In some embodiments, the administration of the nucleic acid or polypeptide compositions provide transient, lasting, or permanent protection against an HBV or HDV infection. In some embodiments, the transient, lasting, or permanent protection against an HBV or HDV infection is superior to other immunogenic compositions. In some embodiments, the administration of the nucleic acid or polypeptide compositions is performed in conjunction with an antiviral therapy. In some embodiments, the administration of the nucleic acid or polypeptide compositions to provide transient, lasting, or permanent protection against an HBV or HDV infection is effective in humans. In some embodiments, the nucleic acid or polypeptide compositions are used as vaccines against HBV or HDV.

[0014] Preferred aspects of the present invention related to the following numbered alternatives:

[0015] 1. An immunogenic composition or product combination comprising:

(a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg) and at least one nucleic acid sequence encoding PreS1; and

(b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence.

[0016] 2. The immunogenic composition or product combination of alternative 1, wherein the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4, or any combination thereof.

[0017] 3. The immunogenic composition or product combination of alternative 1 or 2, wherein the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both.

[0018] 4. The immunogenic composition or product combination of any one of alternatives 1-3, wherein the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence.

[0019] 5. The immunogenic composition or product combination of alternative 4, further comprising at least one nucleic acid sequence encoding an autocatalytic peptide

cleavage site, wherein the grouped HDAg and PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site.

[0020] 6. The immunogenic composition or product combination of alternative 5, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea asigna* virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus.

[0021] 7. The immunogenic composition or product combination of alternative 5 or 6, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13.

[0022] 8. The immunogenic composition or product combination of any one of alternatives 1-7, wherein the nucleic acid is codon optimized for expression in a human.

[0023] 9. The immunogenic composition or product combination of any one of alternatives 1-8, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36.

[0024] 10. The immunogenic composition or product combination of any one of alternatives 1-9, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 18, or SEQ ID NO: 35-36.

[0025] 11. The immunogenic composition or product combination of any one of alternatives 1-10, wherein the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof.

[0026] 12. The immunogenic composition or product combination of any one of alternatives 1-11, wherein the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both.

[0027] 13. The immunogenic composition or product combination of any one of alternatives 1-12, wherein the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence.

[0028] 14. The immunogenic composition or product combination of any one of alternatives 1-13, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37.

[0029] 15. The immunogenic composition or product combination of any of alternatives 1-14, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37.

[0030] 16. The immunogenic composition or product combination of any one of alternatives 1-15, wherein the polypeptide is recombinantly expressed.

[0031] 17. The immunogenic composition or product combination of alternative 16, wherein the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system.

[0032] 18. The immunogenic composition or product combination of any one of alternatives 1-17, further comprising an adjuvant.

[0033] 19. The immunogenic composition or product combination of alternative 18, wherein the adjuvant is alum, QS-21 or MF59, or any combination thereof.

[0034] 20. The immunogenic composition or product combination of any one of alternatives 1-19, wherein the nucleic acid comprises DNA.

[0035] 21. The immunogenic composition or product combination of any one of alternatives 1-20, wherein the nucleic acid is provided in a recombinant vector.

[0036] 22. A method of generating an immune response in a subject using the immunogenic composition or product combination set forth in any one of alternatives 1-21, comprising:

administering to the subject at least one prime dose comprising the nucleic acid; and

administering to the subject at least one boost dose comprising the polypeptide.

[0037] 23. The method of alternative 22, wherein the at least one boost dose further comprises an adjuvant.

[0038] 24. The method of alternative 23, wherein the adjuvant is alum, QS-21, or MF59, or any combination thereof.

[0039] 25. The method of any one of alternatives 22-24, wherein the at least one boost dose is administered at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks

after the at least one prime dose is administered or within a range of time defined by any two of the aforementioned time points e.g., within 1-48 days or 1-48 weeks.

[0040] 26. The method of any one of alternatives 22-25, wherein the administration is provided enterally, orally, intranasally, parenterally, subcutaneously, intramuscularly, intradermally, or intravenously or any combination thereof.

[0041] 27. The method of any one of alternatives 22-26, wherein the administration is performed in conjunction with an antiviral therapy.

[0042] 28. The method of alternative 27, wherein the antiviral therapy comprises administration of entecavir, tenofovir, lamivudine, adefovir, telbivudine, emtricitabine, interferon-α, pegylated interferon-α, or interferon alfa-2b, or any combination thereof.

[0043] 29. An immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D, comprising:

[0044] (a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg) and at least one nucleic acid sequence encoding PreS1; and

[0045] (b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence.

[0046] 30. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 29, wherein the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4, or any combination thereof.

[0047] 31. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 29 or 30, wherein the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both.

[0048] 32. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-31, wherein the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence.

[0049] 33. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 32, further comprising at least one nucleic acid sequence encoding an autocatalytic peptide cleavage site, wherein the grouped HDAg and

PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site.

[0050] 34. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 33, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea asigna* virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus.

[0051] 35. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 33 or 34, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13.

[0052] 36. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-35, wherein the nucleic acid is codon optimized for expression in a human.

[0053] 37. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of alternatives 29-36, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36.

[0054] 38. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-37, wherein the nucleic acid comprises SEQ ID NO: 18, or SEQ ID NO: 35-36.

[0055] 39. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-38, wherein the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof.

[0056] 40. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-39, wherein the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both.

[0057] 41. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-40, wherein the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence.

[0058] 42. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of alternatives 29-41, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37.

[0059] 43. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any of alternatives 29-42, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37.

[0060] 44. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-43, wherein the polypeptide is recombinantly expressed.

[0061] 45. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 44, wherein the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system.

[0062] 46. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-45, further comprising an adjuvant.

[0063] 47. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of alternative 46, wherein the adjuvant is alum, QS-21 or MF59, or any combination thereof.

[0064] 48. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-47, wherein the nucleic acid comprises DNA.

[0065] 49. The immunogenic composition or product combination for use in the treatment of hepatitis B or hepatitis D of any one of alternatives 29-48, wherein the nucleic acid is provided in a recombinant vector.

BRIEF DESCRIPTION OF THE DRAWINGS

[0066] In addition to the features described above, additional features and variations will be readily apparent from the following descriptions of the drawings and exemplary embodiments. It is to be understood that these drawings depict typical embodiments and are not intended to be limiting in scope.

[0067] FIGURES 1A-B depicts the nucleic acid or polypeptide constructs comprising HBV and/or HDV antigens used herein. Ten constructs are provided, Delta-1 (Δ-1, D1), Delta-2 (Δ-2, D2), Delta-3 (Δ-3, D3), Delta-4 (Δ-4, D4), Delta-5 (Δ-5, D5), Delta-6 (Δ-6, D6), Delta-7 (Δ-7, D7), Delta-8 (Δ-8, D8), Delta-9 (Δ-9, D9), and Delta-10 (Δ-10, D10) (FIGURE 1A). Western blot confirms that the ten polypeptide constructs are properly expressed (FIGURE 1B). GFP was used as a control for Western blot.

[0068] FIGURE 2 depicts the constructs used for the DNA prime/protein boost composition approach. The DNA composition comprises the nucleic acid sequence of Δ-4, and the protein composition comprises the polypeptide sequence of either Δ-7 or Δ-8 or a fusion of Δ-7 and Δ-8.

[0069] FIGURES 3A-3E depict the quantification of interferon gamma (IFNγ) forming spots per 10^6 cells on an ELISpot assay, which corresponds to T lymphocyte activation, of a purified white blood cell population from sera derived from mice immunized with HBV/HDV DNA compositions in response to exposure to various HBV or HDV antigens. Antigens include purified polypeptides comprising PreS1 A (**SEQ ID NO: 11**), PreS1 A (**SEQ ID NO: 12**), HDAg genotype 1 A (**SEQ ID NO: 5**, "HDAg gtp 1A-pool 1" and "HDAg gtp 1A-pool 2"), HDAg genotype 1 B (**SEQ ID NO: 6**, "HDAg gtp 1B-pool 3" and "HDAg gtp 1B-pool 4"), HDAg genotype 2 A (**SEQ ID NO:** 7, "HDAg gtp 2C-pool 5" and "HDAg gtp 2C-pool 6") and HDAg genotype 2 B (**SEQ ID NO: 8**, "HDAg gtp 2D-pool 7" and "HDAg gtp 2D-pool 8"). Mice sacrificed 6 weeks after first immunization and pooled splenocytes from each group were stimulated for 48 hours with the HDV peptide pools 1-8 corresponding to genotype 1 (pools 1-4) and genotype 2 (pools 5-8). Pools 1 and 2 of genotype 1 refer to sequence/isolate A while pools 3 and 4 correspond to sequence/isolate B. Similarly, pools 5 and 6 of genotype 2 refer to sequence/isolate C and pools 7 and 8 of genotype 2 refer to sequence/isolate D. Each pool contained 20 or 221 (for pools 1 and 5) 15-mer peptides with 10 aa overlap. Concanavalin A ("ConA") was used as a positive control, and two ovalbumin

peptides ("OVA Th" and "OVA CTL") and growth medium ("media") were used as negative controls. Each peptide-stimulated group were run in triplicates and bars show the mean number of IFNγ spot forming cells (SFC) per 10^6 cells with standard error. A cut-off was set at 100 SFCs/10^6 splenocytes. Concentrations of the antigens are provided.

[0070] FIGURES 4A-4C depict the quantification of anti-PreS1 IgG antibody titer in sera derived from mice immunized with HBV/HDV DNA compositions. Constructs Δ-1 to Δ-10 were tested for generation of IgG antibodies against PreS1A and PreS1B consensus sequences in mice (5 mice per group). FIGURES 4A-4B cover reactivity against PreS1 amino acids 2-48. FIGURE 4C cover cross-reactivity against HBV (sub-) genotypes A1, A2, B, B2, C, D1, E1 and F.

[0071] FIGURES 5A-5C depict the quantification of interferon gamma (IFNγ) forming spots per 10^6 cells on an ELISpot assay of a purified white blood cell population from sera derived from C57BL/6 or HLA-A2 transgenic HHD mice immunized with a Δ-4 DNA composition, or naïve C57BL/6 mice in response to exposure to various HBV or HDV antigens or peptides. Antigens include purified polypeptides comprising PreS1 A (**SEQ ID NO: 11**), PreS1 A (**SEQ ID NO: 12**), a pool comprising HDAg genotypes 1 A and 1 B (**SEQ ID NOs: 5 and 6**, "gtp 1-pool 1", "gtp 1-pool 2", "gtp 1-pool 3", "gtp 1-pool 4"), a pool comprising HDAg genotypes 2 A and 2 B (**SEQ ID NOs: 7 and 8**, "gtp 2-pool B1", "gtp 2-pool B2", "gtp 2-pool B3", "gtp 2-pool B4"), HDAg peptide fragment pools comprising peptides KLEDDNPWL, KLEEENPWL, and FPWDILFPA ("pep-3-pool"), and individual HDAg peptides KLEDDNPWL, KLEEENPWL, and FPWDILFPA. Concanavalin A ("ConA") was used as a positive control, and two ovalbumin peptides ("OVA Th" and "OVA CTL") and growth medium ("media") were used as negative controls. Concentrations of the antigens are provided.

[0072] FIGURES 6A-6C depict the quantification of anti-PreS1 IgG titer in New Zealand white rabbits immunized with Δ-3 or Δ-4 DNA compositions. Serum from the rabbits were collected and tested by ELISA against the PreS1A and PreS1B consensus peptides (FIGURE 6B). The vaccinated rabbit anti-sera also tested for cross-reactivity to HBV (sub-) genotypes A1, A2, B, B2, C, D1, E1, and F (FIGURE 6C). Graph bars show the mean end anti-PreS1 titers for each group determined as the end last serum dilution giving an OD at 405 nm

three times higher than the OD of non-immunized sera at the same dilution. The sera was titrated serially with six-fold dilutions starting at 1:60.

[0073] FIGURE 6D shows the percentage of reactivity of D-4 vaccinated rabbit antisera against PreS1 of different HBV (sub-) genotypes. Six weeks old D-4 vaccinated rabbit antisera were tested for reactivity (at OD 405 nm) against HBV (sub-) genotypes D1, F, A1, C, A2, B, B2 and E1 by ELISA. Using individual 20mer PreS1 peptides with ten aa overlap corresponding to each HBV type of aa 2-21, 12-31, 22-41, and 32-48, neutralizing epitopes mainly localized at aa 22-41 and 32-48 of genotype D1 as indicated by the highest percentage of reactivity, followed by (sub-) types C, E1 and A1 at the same aa region.

[0074] FIGURES 7A-7C depict the quantification of interferon gamma (IFNγ) forming spots per 10^6 cells on an ELISpot assay of a purified white blood cell population from sera derived from C57BL/6 mice immunized with a Δ-4 DNA-only, Δ-7 protein-only, or Δ-4 DNA/Δ-8 protein prime/boost composition. Antigens include purified polypeptides comprising PreS1 A (**SEQ ID NO: 11**), PreS1 A (**SEQ ID NO: 12**), a pool comprising HDAg genotypes 1 A and 1 B (**SEQ ID NOs: 5 and 6**, "gtp 1-pool 1", "gtp 1-pool 2", "gtp 1-pool 3", "gtp 1-pool 4"), and a pool comprising HDAg genotypes 2 A and 2 B (**SEQ ID NOs: 7 and 8**, "gtp 2-pool 5", "gtp 2-pool 6", "gtp 2-pool 7", "gtp 2-pool 8"). Concanavalin A ("ConA") was used as a positive control, and two ovalbumin peptides ("OVA Th" and "OVA CTL"), DMSO, and growth medium ("media") were used as negative controls. Concentrations of the antigens are provided.

[0075] FIGURES 8A-8C depict the quantification of anti-PreS1 IgG titer in C57BL/6 mice immunized with HBV/HDV DNA-only, protein-only, or DNA prime/protein boost compositions.

[0076] FIGURE 9 depicts the quantification of anti-PreS1 IgG titer in rabbits immunized with HBV/HDV DNA-only, protein-only, or DNA prime/protein boost compositions.

[0077] FIGURE 10A-10B depicts the protective effect against HBV infection at 1, 2, 3, 4, 6 and 8 weeks after first inoculation, as determined based on the HBV titers at each time point. Each line indicates one individual mouse (FIGURE 10A). Two negative control mice (grey lines) received non-immunized IgG and three mice (red lines) received D4 PreS1 IgG. One mouse of the PreS1-IgG treated group died at week 4, thus only measurements on

week 1, 2 and 3 are available for this mouse. There were no significant differences between the groups with respect to serum levels of alanine transferase, asparagine transferase, alkaline phosphatase, or bilirubin (FIGURE 10B).

[0078] FIGURE 11A-D depict the assessment of the D-7 and D-8 peptide mixture (10 μg each for administration in mice) with different adjuvants. QS-21, MF59, and alum adjuvants were tested. D-4 DNA compositions administered intramuscularly with electroporation was used as control. FIGURE 11A shows the dosing schedule and exemplary end titers with the tested adjuvants. FIGURE 11B shows % reactivity in individual mice of each condition assessed by ELISA. The x-axis ("1, 3, 10, 30, 0") corresponds to ID numbers of individual mice. FIGURE 11C shows IFNγ activation of splenocytes by HBV PreS1 and HDV antigen consensus peptides as assessed by ELISpot. FIGURE 11D shows end-point PreS1 titers against PreS1A and PreS1B peptides.

[0079] FIGURE 12A-D depict a comparison of D-7 and D-8 peptide mixture only, D-7+D-8 fusion peptide only, and D-4 DNA prime and D-7 and D-8 peptide mixture boost compared to D-4 DNA only and naïve controls. FIGURE 12A shows IFNγ activation of splenocytes by HBV PreS1 and HDV antigen consensus peptides as assessed by ELISpot. FIGURE 12B shows antibody levels against PreS1A assessed 2 weeks after the first round of administration. FIGURE 12C shows antibody levels against PreS1A assessed 2 weeks after the second round of administration. FIGURE 12D shows antibody levels against PreS1B assessed 2 weeks after the second round of administration. The legends for FIGURES 12B-D correspond to ID numbers of individual mice.

DETAILED DESCRIPTION

[0080] Despite preventative vaccines and antiviral therapies, chronic hepatitis B virus (HBV) infection currently affects over 250 million people across the globe. One million chronic carriers die every year due to liver related complications caused by HBV, such as liver cirrhosis and eventually hepatocellular carcinoma (HCC). The hepatitis D virus (HDV), an RNA satellite virus to HBV that "steals" the surface antigen from HBV (HBsAg), co-infects 15-25 million of HBV carriers globally and worsens disease progression. Until now, there is no effective functional cure for chronic HBV or HDV infection. The current standard of care therapy for HBV consists of nucleoside analogues (NAs) that inhibit the reverse transcriptase

(RT) function of the HBV polymerase. This prevents viral maturation by blocking the synthesis of the partially dsDNA inside the capsid. Thus, NAs only suppress the viral replication during therapy. This is due to the fact that blocking of RT neither affects protein production (including HBsAg) and release, nor synthesis of the covalently closed circular DNA, the main cause for HBV persistence. A life-long NA reduces, but does not eliminate, the risk of HCC. A schedule of at least one-year pegylated interferon (IFN)-alpha is the currently recommended treatment for chronic HDV; however, sustained response rates are rare. Combination treatment with pegylated IFN-alpha and NAs has been shown to have limited efficacy against HDV and HBV.

[0081] HBV uses several strategies in order to evade the host immune response. The chronic presence of HBV proteins induces a T cell dysfunction. HBV infected cells overproduce sub-viral HBsAg particles mainly containing small HBsAg (SHBsAg) to block the neutralizing antibody population directed to SHBsAg. This ensures survival of viral particles whose surface are denser with the middle HBsAg (MHBsAg; containing S and PreS2) and large HBsAg (LHBsAg; containing S, PreS2 and PreS1) proteins. Importantly, the PreS1 domain is responsible for binding to the Na^+-taurocholate co-transporting polypeptide (NTCP) receptor for HBV on hepatocytes. Thus, an obvious way to target infectious HBV particles and prevent the infection of new hepatocytes would be to raise antibodies to the PreS1 domain of the virus.

[0082] As disclosed herein, to build an immunotherapy targeting both HBV and HDV infections to induce production of PreS1 antibodies and T cells specific for HBV and HDV, chimeric genes containing PreS1 and the large HDV antigen were generated in different combinations (Figure 1A). The advantage of linking PreS1 to HDAg is that HDAg will act as a heterologous T cell epitope carrier in patients that are mono-infected by HBV. Thus, these HDAg-specific T cells support a sustained endogenous production of PreS1 antibodies that block viral entry and bypass the need for HBV-specific T cells. In fact, >90% of HBV carriers are mono-infected with HBV, and in these patients, the heterologous HDAg will prime healthy naïve T cells that support priming of HBV-specific responses. In addition, it is likely that the HDAg-specific T cells and PreS1 antibodies prevent HDV superinfection in these patients. To induce both neutralizing antibodies and T cells, genetic immunization was used, as this strategy has shown to activate immune response to HBV. Overall, this virus entry-blocking strategy complements the maturation inhibitors and the capsid assembly inhibitors, currently under

development, in order to achieve sustainable off-therapy responses against HBD and/or HDV infection.

[0083] Embodiments provided herein related to immunogenic compositions or product combinations of engineered hepatitis B (HBV) and hepatitis D (HDV) nucleic acids, genes, peptides, or proteins that can be used to illicit an immune response against an HBV or HDV infection. The use of chimeric genes and chimeric proteins comprising HBV and HDV nucleic acids, genes, peptides, or proteins has been characterized, for example, in WO 2017/132332, hereby expressly incorporated by reference in its entirety.

[0084] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0085] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art. All patents, applications, published applications and other publications referenced herein are expressly incorporated by reference in their entireties unless stated otherwise. In the event that there are a plurality of definitions for a term herein, those in this section prevail unless stated otherwise.

[0086] The articles "a" and "an" are used herein to refer to one or to more than one (for example, at least one) of the grammatical object of the article. By way of example, "an element" means one element or more than one element.

[0087] The terms "about" or "around" as used herein refer to a quantity, level, value, number, frequency, percentage, dimension, size, amount, weight or length that varies by as much as 30, 25, 20, 15, 10, 9, 8, 7, 6, 5, 4, 3, 2 or 1% to a reference quantity, level, value, number, frequency, percentage, dimension, size, amount, weight or length.

[0088] Throughout this specification, unless the context requires otherwise, the words "comprise," "comprises," and "comprising" will be understood to imply the inclusion

of a stated step or element or group of steps or elements but not the exclusion of any other step or element or group of steps or elements.

[0089] By "consisting of" is meant including, and limited to, whatever follows the phrase "consisting of." Thus, the phrase "consisting of" indicates that the listed elements are required or mandatory, and that no other elements may be present. By "consisting essentially of" is meant including any elements listed after the phrase, and limited to other elements that do not interfere with or contribute to the activity or action specified in the disclosure for the listed elements. Thus, the phrase "consisting essentially of" indicates that the listed elements are required or mandatory, but that other elements are optional and may or may not be present depending upon whether or not they materially affect the activity or action of the listed elements.

[0090] The practice of the present disclosure will employ, unless indicated specifically to the contrary, conventional methods of molecular biology and recombinant DNA techniques within the skill of the art, many of which are described below for the purpose of illustration. Such techniques are explained fully in the literature. See, e.g. , Sambrook, el al, Molecular Cloning: A Laboratory Manual (3rd Edition, 2000); DNA Cloning: A Practical Approach, vol. 1 & II (D. Glover, ed.); Oligonucleotide Synthesis (N. Gait, ed., 1984); Oligonucleotide Synthesis: Methods and Applications (P. Herdewijn, ed., 2004); Nucleic Acid Hybridization (B. Hames & S. Higgins, eds., 1985); Nucleic Acid Hybridization: Modern Applications (Buzdin and Lukyanov, eds., 2009); Transcription and Translation (B. Hames & S. Higgins, eds., 1984); Animal Cell Culture (R. Freshney, ed., 1986); Freshney, R.I. (2005) Culture of Animal Cells, a Manual of Basic Technique, 5th Ed. Hoboken NJ, John Wiley & Sons; B. Perbal, A Practical Guide to Molecular Cloning (3rd Edition 2010); Farrell, R., RNA Methodologies: A Laboratory Guide for Isolation and Characterization (3rd Edition 2005).

[0091] The term "purity" of any given substance, compound, or material as used herein refers to the actual abundance of the substance, compound, or material relative to the expected abundance. For example, the substance, compound, or material may be at least 80, 85, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100% pure, including all decimals in between. Purity may be affected by unwanted impurities, including but not limited to side products, isomers, enantiomers, degradation products, solvent, carrier, vehicle, or contaminants, or any combination thereof. Purity can be measured technologies including but not limited to

chromatography, liquid chromatography, gas chromatography, spectroscopy, UV-visible spectrometry, infrared spectrometry, mass spectrometry, nuclear magnetic resonance, gravimetry, or titration, or any combination thereof.

[0092] The terms "function" and "functional" as used herein refer to a biological, enzymatic, or therapeutic function.

[0093] The phrases "effective amount" or "effective dose" as used herein refers to an amount sufficient to achieve the desired result and accordingly will depend on the ingredient and its desired result. Nonetheless, once the desired effect is known, determining the effective amount is within the skill of a person skilled in the art.

[0094] In general, the "error bars" provided in the figures represent the standard error of the mean value.

[0095] "Formulation" and "composition" as used interchangeably herein are equivalent terms referring to a composition of matter for administration to a subject.

[0096] The term "isolated" as used herein refers to material that is substantially or essentially free from components that normally accompany it in its native state. For example, an "isolated cell," as used herein, includes a cell that has been purified from the milieu or organisms in its naturally occurring state, a cell that has been removed from a subject or from a culture, for example, it is not significantly associated with in vivo or in vitro substances.

[0097] The term "subject" as used herein has its ordinary meaning as understood in light of the specification and refers to an animal that is the object of treatment, inhibition, or amelioration, observation or experiment. "Animal" has its ordinary meaning as understood in light of the specification and includes cold- and warm-blooded vertebrates and/or invertebrates such as fish, shellfish, or reptiles and, in particular, mammals. "Mammal" has its ordinary meaning as understood in light of the specification, and includes but is not limited to mice, rats, rabbits, guinea pigs, dogs, cats, sheep, goats, cows, horses, primates, such as humans, monkeys, chimpanzees, or apes. In some embodiments, the subject is human.

[0098] Some embodiments disclosed herein related to selecting a subject or patient in need. In some embodiments, a patient is selected who is in need of treatment of a viral infection. In some embodiments, a patient is selected who has previously been treated for a viral infection. In some embodiments, a patient is selected who has previously been treated for being at risk of a viral infection. In some embodiments, a patient is selected who has developed

a recurrence of a viral infection. In some embodiments, a patient is selected who has developed resistance to therapies for a viral infection. In some embodiments, a patient is selected who may have any combination of the aforementioned selection criteria.

[0099] The terms "treating," "treatment," "therapeutic," or "therapy" as used herein has its ordinary meaning as understood in light of the specification, and do not necessarily mean total cure or abolition of the disease or condition. The term "treating" or "treatment" as used herein (and as well understood in the art) also means an approach for obtaining beneficial or desired results in a subject's condition, including clinical results. Beneficial or desired clinical results can include, but are not limited to, alleviation or amelioration of one or more symptoms or conditions, diminishment of the extent of a disease, stabilizing (i.e., not worsening) the state of disease, prevention of a disease's transmission or spread, delaying or slowing of disease progression, amelioration or palliation of the disease state, diminishment of the reoccurrence of disease, and remission, whether partial or total and whether detectable or undetectable. "Treating" and "treatment" as used herein also include prophylactic treatment. Treatment methods comprise administering to a subject a therapeutically effective amount of an active agent. The administering step may consist of a single administration or may comprise a series of administrations. The compositions are administered to the subject in an amount and for a duration sufficient to treat the patient. The length of the treatment period depends on a variety of factors, such as the severity of the condition, the age and genetic profile of the patient, the concentration of active agent, the activity of the compositions used in the treatment, or a combination thereof. It will also be appreciated that the effective dosage of an agent used for the treatment or prophylaxis may increase or decrease over the course of a particular treatment or prophylaxis regime. Changes in dosage may result and become apparent by standard diagnostic assays known in the art. In some instances, chronic administration may be required.

[0100] The term "inhibit" as used herein has its ordinary meaning as understood in light of the specification, and may refer to the reduction or prevention of a viral infection. The reduction can be by 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100%, or an amount that is within a range defined by any two of the aforementioned values. As used herein, the term "delay" has its ordinary meaning as understood in light of the specification, and refers to a slowing, postponement, or deferment of an event, such as a viral infection, to a time which

is later than would otherwise be expected. The delay can be a delay of 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, or an amount within a range defined by any two of the aforementioned values. The terms inhibit and delay may not necessarily indicate a 100% inhibition or delay. A partial inhibition or delay may be realized.

[0101] The term "immunogenic composition" as used herein refers to a substance or mixture of substances, including but not limited to antigens, epitopes, nucleic acids, peptides, polypeptides, proteins, polysaccharides, lipids, haptens, toxoids, inactivated organisms, or attenuated organisms, or any combination thereof, intended to elicit an immune response when administered to a host. The immune response includes both an innate and adaptive immune response, the latter of which establishes a lasting immunological memory through cells such as memory T cells and memory B cells. The antibodies created during the initial immune response to the immunogenic composition can be produced in subsequent challenges of the same antigens, epitopes, nucleic acids, peptides, polypeptides, proteins, polysaccharides, lipids, haptens, toxoids, inactivated organisms, or attenuated organisms, or a live organism or pathogen that exhibits the antigens, epitopes, nucleic acids, peptides, polypeptides, proteins, polysaccharides, lipids, haptens, or toxoids or any combination thereof. In this manner, the immunogenic composition may serve as a vaccine against a specific pathogen. Immunogenic compositions may also include one or more adjuvants to stimulate the immune response and increase the efficacy of protective immunity.

[0102] The term "product combination" as used herein refers to set of two or more individual compounds, substances, materials, or compositions that can be used together for a unified function. In some embodiments, a product combination comprises at least one nucleic acid composition and at least one polypeptide composition that are used together to elicit an immune response when administered to a host, optionally to a greater degree than would be elicited if only one composition type were to be administered.

[0103] The terms "nucleic acid" or "nucleic acid molecule" as used herein refers to polynucleotides, such as deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), oligonucleotides, fragments generated by the polymerase chain reaction (PCR), and fragments generated by any of ligation, scission, endonuclease action, and exonuclease action. Nucleic acid molecules can be composed of monomers that are naturally-occurring nucleotides (such as DNA and RNA), or analogs of naturally-occurring nucleotides (e.g., enantiomeric forms of

naturally-occurring nucleotides), or a combination of both. Modified nucleotides can have alterations in sugar moieties and/or in pyrimidine or purine base moieties. Sugar modifications include, for example, replacement of one or more hydroxyl groups with halogens, alkyl groups, amines, and azido groups, or sugars can be functionalized as ethers or esters. Moreover, the entire sugar moiety can be replaced with sterically and electronically similar structures, such as aza-sugars and carbocyclic sugar analogs. Examples of modifications in a base moiety include alkylated purines and pyrimidines, acylated purines or pyrimidines, or other well-known heterocyclic substitutes. Nucleic acid monomers can be linked by phosphodiester bonds or analogs of such linkages. Analogs of phosphodiester linkages include phosphorothioate, phosphorodithioate, phosphoroselenoate, phosphorodiselenoate, phosphoroanilothioate, phosphoranilidate, or phosphoramidate. The term "nucleic acid molecule" also includes so-called "peptide nucleic acids," which comprise naturally-occurring or modified nucleic acid bases attached to a polyamide backbone. Nucleic acids can be either single stranded or double stranded. "Oligonucleotide" can be used interchangeable with nucleic acid and can refer to either double stranded or single stranded DNA or RNA. A nucleic acid or nucleic acids can be contained in a nucleic acid vector or nucleic acid construct (e.g. plasmid, virus, bacteriophage, cosmid, fosmid, phagemid, bacterial artificial chromosome (BAC), yeast artificial chromosome (YAC), or human artificial chromosome (HAC)) that can be used for amplification and/or expression of the nucleic acid or nucleic acids in various biological systems. Typically, the vector or construct will also contain elements including but not limited to promoters, enhancers, terminators, inducers, ribosome binding sites, translation initiation sites, start codons, stop codons, polyadenylation signals, origins of replication, cloning sites, multiple cloning sites, restriction enzyme sites, epitopes, reporter genes, selection markers, antibiotic selection markers, targeting sequences, peptide purification tags, or accessory genes, or any combination thereof.

[0104] A nucleic acid or nucleic acid molecule can comprise one or more sequences encoding different peptides, polypeptides, or proteins. These one or more sequences can be joined in the same nucleic acid or nucleic acid molecule adjacently, or with extra nucleic acids in between, e.g. linkers, repeats or restriction enzyme sites, or any other sequence that is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 150, 200, or 300 bases long, or any length in a range defined by

any two of the aforementioned lengths. The term "downstream" on a nucleic acid as used herein refers to a sequence being after the 3'-end of a previous sequence, on the strand containing the encoding sequence (sense strand) if the nucleic acid is double stranded. The term "upstream" on a nucleic acid as used herein refers to a sequence being before the 5'-end of a subsequent sequence, on the strand containing the encoding sequence (sense strand) if the nucleic acid is double stranded. The term "grouped" on a nucleic acid as used herein refers to two or more sequences that occur in proximity either directly or with extra nucleic acids in between, e.g. linkers, repeats, or restriction enzyme sites, or any other sequence that is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 150, 200, or 300 bases long, or any length in a range defined by any two of the aforementioned lengths, but generally not with a sequence in between that encodes for a functioning or catalytic polypeptide, protein, or protein domain.

[0105] The term "codon optimized" regarding a nucleic acid as used herein refers to the substitution of codons of the nucleic acid to enhance or maximize translation in a host of a particular species without changing the polypeptide sequence based on species-specific codon usage biases and relative availability of each aminoacyl-tRNA in the target cell cytoplasm. Codon optimization and techniques to perform such optimization is known in the art. Programs containing algorithms for codon optimization are known to those skilled in the art. Programs can include, for example, OptimumGene, GeneGPS® algorithms, etc. Additionally, synthetic codon optimized sequences can be obtained commercially for example from Integrated DNA Technologies and other commercially available DNA sequencing services. Those skilled in the art will appreciate that gene expression levels are dependent on many factors, such as promoter sequences and regulatory elements. As noted for most bacteria, small subsets of codons are recognized by tRNA species leading to translational selection, which can be an important limit on protein expression. In this aspect, many synthetic genes can be designed to increase their protein expression level.

[0106] The nucleic acids described herein comprise nucleobases. Primary, canonical, natural, or unmodified bases are adenine, cytosine, guanine, thymine, and uracil. Other nucleobases include but are not limited to purines, pyrimidines, modified nucleobases, 5-methylcytosine, pseudouridine, dihydrouridine, inosine, 7-methylguanosine, hypoxanthine,

xanthine, 5,6-dihydrouracil, 5-hydroxymethylcytosine, 5-bromouracil, isoguanine, isocytosine, aminoallyl bases, dye-labeled bases, fluorescent bases, or biotin-labeled bases.

[0107] The terms "peptide", "polypeptide", and "protein" as used herein refers to macromolecules comprised of amino acids linked by peptide bonds. The numerous functions of peptides, polypeptides, and proteins are known in the art, and include but are not limited to enzymes, structure, transport, defense, hormones, or signaling. Peptides, polypeptides, and proteins are often, but not always, produced biologically by a ribosomal complex using a nucleic acid template, although chemical syntheses are also available. By manipulating the nucleic acid template, peptide, polypeptide, and protein mutations such as substitutions, deletions, truncations, additions, duplications, or fusions of more than one peptide, polypeptide, or protein can be performed. These fusions of more than one peptide, polypeptide, or protein can be joined in the same molecule adjacently, or with extra amino acids in between, e.g. linkers, repeats, epitopes, or tags, or any other sequence that is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 150, 200, or 300 bases long, or any length in a range defined by any two of the aforementioned lengths.

[0108] In some embodiments, the nucleic acid or peptide sequences presented herein and used in the examples are functional in various biological systems including but not limited to humans, mice, rabbits, *E. coli*, yeast, and mammalian cells. In other embodiments, nucleic acid or peptide sequences sharing 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% similarity, or any percentage within a range defined by any two of the aforementioned percentages similarity to the nucleic acid or peptide sequences presented herein and used in the examples can also be used with no effect on the function of the sequences in biological systems. As used herein, the term "similarity" refers to a nucleic acid or peptide sequence having the same overall order of nucleotide or amino acids, respectively, as a template nucleic acid or peptide sequence with specific changes such as substitutions, deletions, repetitions, or insertions within the sequence. In some embodiments, two nucleic acid sequences sharing as low as 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% similarity can encode for the same polypeptide by comprising different codons that encode for the same amino acid during translation.

[0109] The term "recombinantly expressed" as used herein refers to the production of proteins in optimized or adapted biological systems. These systems provide advantages over protein expression in a natural host, including but not limited to high expression (overexpression), ease of purification, ease of transformation, inducibility, low cost, or stability of the protein. In some embodiments, proteins are expressed in mammalian, bacteria, yeast, insect, or cell-free recombinant expression systems. Each system has its own advantages or disadvantages. For example, bacterial expression systems are highly optimized for overexpression, but may cause misfolding or aggregation of the produced protein, yeast systems are useful when post-translational modifications are necessary, and insect and mammalian systems are useful for proper RNA splicing that occurs in higher-order organisms. In some embodiments, Δ-7, Δ-8, and other recombinant polypeptides are produced and purified from mammalian, human, primary, immortalized, cancer, stem, fibroblasts, human embryonic kidney (HEK) 293, Chinese Hamster Ovary (CHO), bacterial, *Escherichia coli*, yeast, *Saccharomyces cerevisiae*, *Pichia pastoris*, insect, *Spodoptera frugiperda Sf9*, or *S. frugiperda Sf*21 cells, or in a cell-free system. In some embodiments, expression genes, vectors, or constructs are delivered to the recombinant expression systems in the form of plasmids, bacteriophages, viruses, adeno-associated viruses (AAVs), baculovirus, cosmids, fosmids, phagemids, BACs, YACs, or HACs. For more discussion on recombinant expression systems, see Gomes et al. "An Overview of Heterologous Expression Host Systems for the Production of Recombinant Proteins" ((2016) Adv. Anim. Vet. Sci. 4(7):346-356), hereby expressly incorporated by reference in its entirety.

[0110] The term "HDAg" as used herein refers the hepatitis D antigen gene or protein. A small (24 kDa) and large (27 kDa, 213 amino acids excluding the start methionine) isoform exist for HDAg and are translated from the same open reading frame on the HDV genome. Deamination of the adenosine in a UAG stop codon at codon 196 of the coding sequence allows for translation to continue and produce the large isoform. Unless expressly stated otherwise, the embodiments described herein comprise the large isoform of HDAg. In some embodiments, the HDAg sequences comprise at least one of four different HDAg strain sequences: "HDAg genotype 1 A", "HDAg genotype 1 B", "HDAg genotype 2 A", or "HDAg genotype 2 B". In some embodiments, the nucleic acid sequence encoding at least one HDAg polypeptide comprises the nucleic acid sequence of HDAg genotype 1 A (**SEQ ID NO: 1**),

HDAg genotype 1 B (**SEQ ID NO: 2**), HDAg genotype 2 A (**SEQ ID NO: 3**), or HDAg genotype 2 B (**SEQ ID NO: 4**). In some embodiments, the polypeptide comprising at least one HDAg polypeptide comprises the polypeptide sequence of HDAg genotype 1 A (**SEQ ID NO: 5**), HDAg genotype 1 B (**SEQ ID NO: 6**), HDAg genotype 2 A (**SEQ ID NO: 7**), or HDAg genotype 2 B (**SEQ ID NO: 8**).

[0111] The term "PreS1" as used herein refers to a segment of the N-terminal domain on the large surface antigen of HBV (HBsAg). A 47 amino acid long PreS1 segment of the 108-119 amino acid long N-terminal domain of the large HBsAg is effective in eliciting an immune response and generating high titer of anti-PreS1/anti-HBV antibodies in mammalian models. In some embodiments, the PreS1 sequences comprise at least one of two different PreS1 consensus sequences: "PreS1 A" and/or "PreS1 B". In some embodiments, the nucleic acid sequence encoding at least one PreS1 polypeptide comprises the nucleic acid sequence of PreS1 A (**SEQ ID NO: 9**) or PreS1 B (**SEQ ID NO: 10**). In some embodiments, the polypeptide comprising at least one PreS1 polypeptide comprises the polypeptide sequence of PreS1 A (**SEQ ID NO: 11**) or PreS1 B (**SEQ ID NO: 12**).

[0112] In some embodiments, the PreS1 A and PreS1 B consensus sequences of HBV are obtained or derived from sequence similarity of PreS1 in known genotypes of HBV. There are ten known or prevalent HBV genotypes (genotypes A, B, C, D, E, F, G, H, I , and J) exhibiting up to or about 8% nucleotide differences in genomic sequence. Of these, there are additional sub-genotypes exhibiting up to or about 4%-8% nucleotide differences in genomic sequence. Sub-genotypes of HBV include but are not limited to A1, A2, A3, A4, A5, A6, A7, B2, B3, B4, B5, B6, B7, B9, C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, D1, D2, D3, D4, D5, D6, D7, F1, F2, F2a, F3, or F4. For more discussion on HBV genotypes, see Sunbul "Hepatitis B virus genotypes: Global distribution and clinical importance" ((2014) World. J. Gastroenterology. 20(18):5427-5434, hereby expressly incorporated by reference in its entirety.

[0113] The terms "autocatalytic peptide cleavage site" or "2A peptide" as used herein refer to a peptide sequence that undergo cleavage of a peptide bond between two constituent amino acids, resulting in separation of the two proteins that flank the sequence. The cleavage is believed to be a result of a ribosomal "skipping" of the peptide bond formation between the C-terminal proline and glycine in the 2A peptide sequence. Four autocatalytic peptide cleavage

site sequences identified to date have seen substantial use in biomedical research: foot-and-mouth disease virus 2A (F2A); equine rhinitis A virus (ERAV) 2A (E2A); porcine teschovirus-1 2A (P2A), and *Thosea asigna* virus 2A (T2A). In some embodiments, the P2A autocatalytic peptide cleavage site nucleic acid (**SEQ ID NO: 13**) and polypeptide (**SEQ ID NO: 14**) sequences are used.

[0114] The term "HBeAg" as used herein refers to an HBV antigen protein found between the nucleocapsid core and lipid envelope of the virus. HBeAg produced in a host is secreted into the blood serum and is a good marker for an active HBV infection. Quantification of *in vitro* HBeAg secretion in a cell culture model can be used to assess effect of biological or pharmaceutical compounds or compositions on HBV infectivity.

[0115] The term "excipient" has its ordinary meaning as understood in light of the specification, and refers to other substances, compounds, or materials found in an immunogenic composition or vaccine. Excipients with desirable properties include but are not limited to preservatives, adjuvants, stabilizers, solvents, buffers, diluents, solubilizing agents, detergents, surfactants, chelating agents, antioxidants, alcohols, ketones, aldehydes, ethylenediaminetetraacetic acid (EDTA), citric acid, salts, sodium chloride, sodium bicarbonate, sodium phosphate, sodium borate, sodium citrate, potassium chloride, potassium phosphate, magnesium sulfate sugars, dextrose, fructose, mannose, lactose, galactose, sucrose, sorbitol, cellulose, serum, amino acids, polysorbate 20, polysorbate 80, sodium deoxycholate, sodium taurodeoxycholate, magnesium stearate, octylphenol ethoxylate, benzethonium chloride, thimerosal, gelatin, esters, ethers, 2-phenoxyethanol, urea, or vitamins, or any combination thereof. Some excipients may be in residual amounts or contaminants from the process of manufacturing the immunogenic composition or vaccine, including but not limited to serum, albumin, ovalbumin, antibiotics, inactivating agents, formaldehyde, glutaraldehyde, β-propiolactone, gelatin, cell debris, nucleic acids, peptides, amino acids, or growth medium components or any combination thereof. The amount of the excipient may be found in an immunogenic composition or vaccine at a percentage of 0%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 100% w/w or any percentage by weight in a range defined by any two of the aforementioned numbers.

[0116] The term "adjuvant" as used herein refers to a substance, compound, or material that stimulates the immune response and increase the efficacy of protective immunity and is administered in conjunction with the immunogenic antigen, epitope, or composition. Adjuvants serve to improve immune responses by enabling a continual release of antigen, up-regulation of cytokines and chemokines, cellular recruitment at the site of administration, increased antigen uptake and presentation in antigen presenting cells, or activation of antigen presenting cells and inflammasomes. Commonly used adjuvants include but are not limited to alum, aluminum salts, aluminum sulfate, aluminum hydroxide, aluminum phosphate, calcium phosphate hydroxide, potassium aluminum sulfate, oils, mineral oil, paraffin oil, oil-in-water emulsions, detergents, MF59®, squalene, AS03, α-tocopherol, polysorbate 80, AS04, monophosphoryl lipid A, virosomes, nucleic acids, polyinosinic:polycytidylic acid, saponins, QS-21, proteins, flagellin, cytokines, chemokines, IL-1, IL-2, IL-12, IL-15, IL-21, imidazoquinolines, CpG oligonucleotides, lipids, phospholipids, dioleoyl phosphatidylcholine (DOPC), trehalose dimycolate, peptidoglycans, bacterial extracts, lipopolysaccharides, or Freund's Adjuvant, or any combination thereof.

[0117] The terms "prime" and "boost" as used herein related to separate immunogenic compositions used in a heterologous prime-boost immunization approach. Immunizations or vaccines commonly require more than one administration of an immunogenic composition to induce a successful immunity against a target pathogen in a host. Compared to this homologous approach where the same composition is provided for all administrations, a heterologous prime-boost administration may be more effective in establishing robust immunity with greater antibody levels and improved clearing or resistance against some pathogens such as HBV or HDV. In a heterologous prime-boost administration, at least one prime dose comprising one type of immunogenic composition is first provided. After the at least one prime dose is provided, at least one boost dose comprising another type of immunogenic composition is then provided. Administration of the at least one boost dose is performed at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks after the at least one prime dose is administered or within a range of time defined by any two of the aforementioned time points e.g., within 1-48 days or 1-48 weeks. In some embodiments, the prime dose comprises a nucleic acid (e.g. DNA or RNA) that encodes for one or more antigens or epitopes, and the boost dose comprises a polypeptide that comprises one or more antigens

or epitopes. In the host, the nucleic acid prime is translated *in vivo* to elicit an immune reaction and causes a greater response against the subsequent polypeptide boost. In some embodiments, the nucleic acid prime comprises sequences that encodes for at least one HDAg polypeptide, at least one PreS1 peptide, and at least one autocatalytic peptide cleavage site. In some embodiments, the polypeptide boost comprises at least one HDAg polypeptide and at least one PreS1 polypeptide.

[0118] In some embodiments, administration of the nucleic acid prime and polypeptide boost comprising HBV and HDV components in an experimental organism results in greater anti-HDAg, anti-PreS1, anti-HBV, or anti-HDV antibody titer at a ratio of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 50, 100, 150, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 5000, 10000, 100000, or 1000000 or any ratio within a range defined by any two of the aforementioned ratios compared to nucleic acid-only or polypeptide-only immunized, or unimmunized control organisms, quantified by techniques known in the art such as ELISA. In some embodiments, administration of the nucleic acid prime and polypeptide boost comprising HBV and HDV components in an experimental organism results in serum that neutralizes HBV or HDV infectivity *in vitro* more effectively and reduces the incidence of infection to a ratio of 0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, or 1.0 or any ratio within a range defined by any two of the aforementioned ratios compared to sera from nucleic acid-only or polypeptide-only immunized, or unimmunized control organisms. In some embodiments, administration of the nucleic acid prime and polypeptide boost comprising HBV and HDV components in an experimental organism results in a greater number of interferon gamma (IFNγ)-positive cells (e.g. T cells) at a ratio of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000, 5000, or 10000, or any ratio within a range defined by any two of the aforementioned ratios compared to nucleic acid-only or polypeptide-only immunized, or unimmunized control organisms.

[0119] In some embodiments, the immunogenic compositions or product combinations are administered with an adjuvant. In some embodiments, the immunogenic compositions or product combinations are administered enterally, orally, intranasally, parenterally, subcutaneously, intramuscularly, intradermally, or intravenously or any

combination thereof. In some embodiments, the immunogenic compositions or product combinations are administered in conjunction with an antiviral therapy compound known to have an effect against HBV or HDV, including but not limited to entecavir, tenofovir, lamivudine, adefovir, telbivudine, emtricitabine, interferon-α, pegylated interferon-α, or interferon alfa-2b, or any combination thereof.

[0120] The terms "*in vivo* electroporation", "electroporation", and "EP" as used herein refers to the delivery of genes, nucleic acids, DNA, RNA, proteins, or vectors into cells of living tissues or organisms using electrical currents using techniques known in the art. Electroporation can be used as an alternative to other methods of gene transfer such as viruses (transduction), lipofection, gene gun (biolistics), microinjection, vesicle fusion, or chemical transformation. Electroporation limits the risk of immunogenicity and detrimental integration or mutagenesis of the cell genome. DNA vectors such as plasmids are able to access the cell nucleus, enabling transcription and translation of constituent genes. In some embodiments, the genes, nucleic acids, DNA, RNA, proteins, or vectors are added to the target tissue or organism by subcutaneous, intramuscular, or intradermal injection. An electroporator then delivers short electrical pulses via electrodes placed within or proximal to the injected sample. As used herein, the term "im/EP" refers to *in vivo* electroporation of a sample delivered intramuscularly ("im").

[0121] The term "uPA$^{+/+}$-SCID" as used herein refers to an immunodeficient mouse model used for studying liver diseases including hepatitis viral infections. These mice are homozygous for *Prkdc*^{scid}, causing deficiencies in functional T and B lymphocytes. Overexpression of urokinase-type plasminogen activator (uPA) also causes severe liver cytotoxicity and hepatic insufficiency during development. Subsequent transplantation and engraftment of human liver tissue to these mice results in a model ideal for studying hepatic illnesses of humans. For more discussion on uPA$^{+/+}$-SCID mice, see Meuleman et al. "The human liver-uPA-SCID mouse: A model for the evaluation of antiviral compounds against HBV and HCV" ((2008) Antiviral Research 80(3):231-238), hereby expressly incorporated by reference in its entirety.

[0122] The term "% w/w" or "% wt/wt" as used herein has its ordinary meaning as understood in light of the specification and refers to a percentage expressed in terms of the weight of the ingredient or agent over the total weight of the composition multiplied by 100.

The term "% v/v" or "% vol/vol" as used herein has its ordinary meaning as understood in the light of the specification and refers to a percentage expressed in terms of the liquid volume of the compound, substance, ingredient, or agent over the total liquid volume of the composition multiplied by 100.

[0123] The invention is generally disclosed herein using affirmative language to describe the numerous embodiments. The invention also includes embodiments in which subject matter is excluded, in full or in part, such as substances or materials, method steps and conditions, protocols, or procedures.

Immunogenic compositions and product combinations

[0124] Disclosed herein are immunogenic compositions or product combinations. In some embodiments, these immunogenic compositions or product combinations are intended to induce an immunogenic response against a particular antigen. In some embodiments, the immunogenic compositions or product combinations comprise (a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg) and at least one nucleic acid sequence encoding PreS1; and (b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence. In some embodiments, the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4, or any combination thereof. In some embodiments, the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both. In some embodiments, the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence. In some embodiments, the immunogenic compositions or product combinations further comprise at least one nucleic acid sequence encoding an autocatalytic peptide cleavage site, wherein the grouped HDAg and PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site. In some embodiments, the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea asigna* virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus. In some

embodiments, the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13. In some embodiments, the nucleic acid is codon optimized for expression in a human. In some embodiments, the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36. In some embodiments, the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 18, or SEQ ID NO: 35-36. In some embodiments, the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof. In some embodiments, the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both. In some embodiments, the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence. In some embodiments, the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37. In some embodiments, the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37. In some embodiments, the polypeptide is recombinantly expressed. In some embodiments, the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system. In some embodiments, the immunogenic compositions or product combinations further comprise an adjuvant. In some embodiments, the adjuvant is alum, QS-21 or MF59, or any combination thereof. In some embodiments, the nucleic acid comprises DNA. In some embodiments, the nucleic acid is provided in a recombinant vector.

[0125] Also disclosed herein are methods of generating an immune response in a subject using an immunogenic composition or product combination. In some embodiments, the immunogenic composition or product combination is any one of the immunogenic compositions or product combinations disclosed herein. In some embodiments, the methods comprises administering to the subject at least one prime dose comprising the nucleic acid; and administering to the subject at least one boost dose comprising the polypeptide. In some embodiments, the at least one boost dose further comprises an adjuvant. In some embodiments, the adjuvant is alum, QS-21, or MF59, or any combination thereof. In some embodiments, the at least one boost dose is administered at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks after the at least one prime dose is administered or within a range of time defined by any two of the aforementioned time points e.g., within 1-48 days or 1-48 weeks. In some

embodiments, the administration is provided enterally, orally, intranasally, parenterally, subcutaneously, intramuscularly, intradermally, or intravenously or any combination thereof. In some embodiments, the administration is performed in conjunction with an antiviral therapy. In some embodiments, the antiviral therapy comprises administration of entecavir, tenofovir, lamivudine, adefovir, telbivudine, emtricitabine, interferon-α, pegylated interferon-α, or interferon alfa-2b, or any combination thereof.

[0126] Also disclosed herein are immunogenic compositions or product combinations for use in the treatment or inhibition of hepatitis B or hepatitis D. In some embodiments, the immunogenic compositions or product combinations are any one of the immunogenic compositions or product combinations disclosed herein. In some embodiments, the immunogenic compositions or product combinations comprise (a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg), and at least one nucleic acid sequence encoding PreS1; and (b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence. In some embodiments, the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4. In some embodiments, the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both. In some embodiments, the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence. In some embodiments, the immunogenic compositions or product combinations further comprise at least one nucleic acid sequence encoding an autocatalytic peptide cleavage site, wherein the grouped HDAg and PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site. In some embodiments, the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea asigna* virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus. In some embodiments, the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13. In some embodiments, the nucleic acid is codon

optimized for expression in a human. In some embodiments, the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36. In some embodiments, the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 18, or SEQ ID NO: 35-36. In some embodiments, the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof. In some embodiments, the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both. In some embodiments, the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence. In some embodiments, the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37. In some embodiments, the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37. In some embodiments, the polypeptide is recombinantly expressed. In some embodiments, the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system. In some embodiments, the immunogenic compositions or product combinations further comprise an adjuvant. In some embodiments, the adjuvant is alum, QS-21, or MF59, or any combination thereof. In some embodiments, the nucleic acid comprises DNA. In some embodiments, the nucleic acid is provided in a recombinant vector.

EXAMPLES

[0127] Some aspects of the embodiments discussed above are disclosed in further detail in the following examples, which are not in any way intended to limit the scope of the present disclosure. Those in the art will appreciate that many other embodiments also fall within the scope of the invention, as it is described herein above and in the claims.

Example 1: Methodology

Animals

[0128] Female C57BL/6 (H-2^b) mice were obtained from Charles River Laboratories. Human leukocyte antigen A2 (HLA-A2) transgenic HHD mice were bred inhouse. All mice were 8-10 weeks old at the start of the experiments and maintained under

standard conditions. uPA$^{+/+}$-SCID mice with humanized liver were produced and maintained. New Zealand White rabbits were purchased from commercial vendors.

DNA Plasmids

[0129] Plasmids encoding for genotypes 1 and 2 of the L-HDAg and the PreS1 domain (aa 2-48) of the HBsAg, were used in this study as fusion constructs, optionally cleaved by a P2A, consisting of different combinations of HDAg/PreS1 sequences. The HDAg sequences of genotypes 1 and 2 obtained from four different clinical isolates; US-2 and CB, and 7/18/83 and TW2476, respectively. All genes were cloned into the pVAX1 backbone (Invitrogen, Carlsbad, CA) using restriction sites EcoR I and HindIII. Plasmids were grown in TOP10 *E.coli* cells (Life Technologies, Carlsbad, CA) and purified for in vivo injections using Qiagen Endofree DNA purification kit (Qiagen GmbH) following manufacturer's instructions. The correct gene size was confirmed by restriction enzyme digests using EcoR I and HindIII (Fast Digest, Thermo Fisher Scientific).

Western Blot

[0130] Western Blot was essentially performed as generally known in the art. Hela cells were transfected with each pVAX1 D1-D10 DNA plasmids and pVAX1 with the reporter gene GFP as control, using Lipofectamine® 3000 Transfection Reagent (Thermo Fisher Scientific). For protein detection, serum from the D4 vaccinated rabbit diluted 1:1000 (primary antibody) and goat anti-Rabbit Immunoglobulins HRP 0.25g/L (DAKO) diluted 1:4000 (secondary antibody) used. For Chemiluminescence detection, Pierce TM ECL Plus Western Blotting Substrate was used and images were collected with Gel Doc XR+ System (Biorad).

Peptides

[0131] A total of 168 HDAg 15-mer peptides with 10 aa overlap were purchased from Sigma-Aldrich (St. Louis, MO). The 168 peptides were divided in 8 pools each containing 20 or 21 peptides. Four pools correspond to genotype 1 (pool $1_{1\text{-}21}$, pool $2_{22\text{-}42}$, pool $3_{43\text{-}63}$ and pool $4_{64\text{-}84}$) and four pools correspond to genotype 2 (pool $1_{1\text{-}21}$, pool $2_{22\text{-}42}$, pool $3_{43\text{-}}$

63 and pool 464-84) for sequences A, B, C and D with each sequence referring to each clinical isolate.

[0132] Two consensus sequences of the PreS1 HBsAg (PreS1A and PreS1B) consisting of 47 aa and 20-mer PreS1 peptides with 10 aa overlap for HBV (sub-) genotypes A1, A2, B, B2, C, D1, E1 and F were purchased from Sigma-Aldrich (St. Louis, MO). All peptides have passed QC (Sigma-Aldrich PEPscreen® Directory) and have purity >70%. OVA 257-264 CTL (SIINFEKL (SEQ ID NO: 38)) and OVA 323-339 Th (ISQAVHAAHAEINEAGR (SEQ ID NO: 39)) ovalbumin peptides were used as negative peptide controls while Concanavalin A (ConA) purchased from Sigma Aldrich (St. Louis, MO) was used as positive control at final concentration of 0.5μg/μL.

Immunization protocols for evaluating immunogenicity of HBV/HDV plasmids in mice and rabbits

[0133] To evaluate the immunogenicity of the constructs in vivo, mice and rabbits were immunized essentially as described boosted at monthly intervals and sacrificed two weeks later for spleens and blood collection. In brief, female C57BL/6 mice (five per group) were immunized intramuscularly (i.m.) in the tibialis cranialis anterior (TA) muscle with 50 μg plasmid DNA in a volume of 50 μL in sterile PBS by regular needle (27G) injection followed by in vivo electroporation (EP) using the Cliniporator2 device (IGEA, Carpi, Italy). During in vivo electroporation, a 1 ms 600 V/cm pulse followed by a 400 ms 60 V/cm pulse pattern was used to facilitate better uptake of the DNA. Prior to vaccine injections, mice were given analgesic and kept under isoflurane anesthesia during the vaccinations. For studies in rabbits, two New Zealand White rabbits per group were immunized with 300μg D3 and D4 DNA vaccines. Vaccines were administered by i.m. injection in 300μL sterile PBS to the right TA muscle followed by in vivo EP.

Detection of IFNγ producing T cells by Enzyme-Linked Immunospot Assay (ELISpot)

[0134] Two weeks after last vaccination, splenocytes from each immunized group of mice pooled (five mice/group) and tested for their ability to induce HBV/HDV-specific T cells based on IFN-γ secretion after peptide stimulation for 48h as known in the art using a commercially available ELISpot assay (Mabtech, Nacka Strand, Sweden).

Antibody detection by ELISA

[0135] Detection of mouse and rabbit IgG against PreS1 consensus and overlapping 20mer- peptides (10μg/mL) was performed using protocols known in the art. Antibody titers determined as endpoint serum dilutions at which the OD value at 405 nm is at least twice the OD of the negative control (non-immunized or control animal serum) at the same dilution.

HBV neutralization assay in human-liver uPA-SCID mouse model

[0136] HepG2-NTCP-A3 is a selected cell clone derived from the HepG2 cell expressing human NTCP as described previously. It was cultivated in DMEM medium supplemented with 10% fetal calf serum, 2 mM l-glutamine, 50 U/mL penicillin, and 50 μg/mL streptomycin. During and after inoculation, 2.5% DMSO was added to the medium to enhance HBV infection and replication. HBV virus stock used for infection was prepared from HepAD38 cells by PEG precipitation as described. Cell culture medium between day 3-6 post infection were collected and diluted 1:5 with PBS for ELISA analysis of HBeAg quantification using commercial antibodies.

Statistical analysis

[0137] Data was analyzed using GraphPad Prism V.5 and V.8 software and Microsoft Excel V.16.13.1.

Example 2: HBV and HDV immunogenic constructs

[0138] The use of recombinant HBV and HDV polypeptide constructs have been shown to be effective in eliciting antibody formation and immune protection against the two hepatitis viruses, for example, in WO 2017/132332, hereby expressly incorporated by reference in its entirety. These recombinant polypeptide constructs were assembled by combining HDAg chosen from four distinct HDV genotypes (HDAg genotype 1 A, HDAg genotype 1 B, HDAg genotype 2 A, and HDAg genotype 2 B), PreS1 chosen from two genotype consensus sequences (PreS1 A and PreS1B), and one or more P2A autocatalytic peptide cleavage sites. Schematics for eleven recombinant constructs are shown in Figures 1A and 2, and corresponding SEQ ID NOs for DNA and polypeptide sequences, if applicable, are

provided in Table 1. A Western blot confirms that polypeptides properly express from Δ-1 to Δ-10 recombinant constructs (Figure 1B).

Table 1: SEQ ID NOs for the HBV/HDV immunogenic constructs

Name	Human codon optimized DNA Sequence	Polypeptide Sequence
Δ-1 (Delta-1; D1)	SEQ ID NO: 15	SEQ ID NO: 25
Δ-2 (Delta-2; D2)	SEQ ID NO: 16	SEQ ID NO: 26
Δ-3 (Delta-3; D3)	SEQ ID NO: 17	SEQ ID NO: 27
Δ-4 (Delta-4; D4)	SEQ ID NO: 18	SEQ ID NO: 28
Δ-5 (Delta-5; D5)	SEQ ID NO: 19	SEQ ID NO: 29
Δ-6 (Delta-6; D6)	SEQ ID NO: 20	SEQ ID NO: 30
Δ-7 (Delta-7; D7)	SEQ ID NO: 21	SEQ ID NO: 31
Δ-8 (Delta-8; D8)	SEQ ID NO: 22	SEQ ID NO: 32
Δ-9 (Delta-9; D9)	SEQ ID NO: 23	SEQ ID NO: 33
Δ-10 (Delta-10; D10)	SEQ ID NO: 24	SEQ ID NO: 34
Δ-7 + Δ-8 fusion (Delta-7+Delta-8; D-7+D8)	SEQ ID NO: 36 (Wild type sequence: SEQ ID NO: 35)	SEQ ID NO: 37

Example 3: HBV/HDV DNA compositions induce immunogenic response in mice

[0139] While immunogenic compositions and vaccines have traditionally been either whole organisms or antigenic proteins, it has been recently shown that *in vivo* administration of DNA to living tissue and the subsequent transcription and translation of antigenic proteins are also highly effective in triggering an immune response. These DNA immunogenic compositions are being explored as potential vaccine candidates against various diseases.

[0140] Following 2 weeks after the second administration of the DNA construct compositions, immunity of the mice against HBV and HDV antigens were assessed. White blood cells were purified from mouse whole blood samples and incubated with purified polypeptide antigens, including PreS1 A, PreS1 B, HDAg genotypes 1 A, 1 B, 2 A, and 2 B. Cells were also incubated with Concanavalin A ("ConA") as a positive control, and two ovalbumin peptides ("OVA Th" and "OVA CTL") as negative controls. The population frequency of interferon gamma (IFNγ) producing cells in response to antigen exposure was assessed by enzyme-linked immunospot assay (ELISpot). Briefly, white blood cells were incubated with antigen in wells coated with IFNγ antibodies. The cells were then removed, and biotinylated IFNγ antibodies, alkaline phosphatase-crosslinked streptavidin, and alkaline

phosphatase substrate colorimetric reagents were added to the wells in succession with thorough washing in between. The plate was then allowed to dry and the remaining colored spots that correspond to IFNγ-secreting cells were counted by microscopy. The quantitative total of IFNγ spot forming cells per 10^6 total cells in response to the various peptide antigens for each of the mice are shown in Figures 3A (Δ-1 and Δ-2), 3B (Δ-3 and Δ-4), 3C (Δ-5 and Δ-6), 3D (Δ-7 and Δ-8), and 3E (Δ-9 and Δ-10).

[0141] Anti-sera were tested for reactivity against PreS1A and PreS1B consensus peptides (aa 2-48) and for cross-reactivity against HBV (sub-) types A1, A2, B, B2, C, D1, E1 and F using pools of 20-mer PreS1-peptides. Immunogenic compositions comprising Δ-1, Δ-2, Δ-3, Δ-4, Δ-7, and Δ-8 resulted in robust immunogenicity against both HBV PreS1 antigens (Figures 4A-B). Δ-3 and Δ-4 induced antibody titers $>10^4$ in mice, followed by constructs Δ-1, Δ-2, Δ-7 and Δ-8. Importantly, anti-sera from Δ-4 and Δ-7 immunized mice effectively cross-reacted between all tested HBV types (Figure 4C). The immune response to HDAg peptides were more variable, likely due to differences in genotypic sequences, but typically greater than the ovalbumin controls. Notably, in Δ-3 and Δ-4 treated groups, a slight reduction in HDV T cell responses is observed when i.e. compared to constructs that contain only HDAg (Δ-5, Δ-6, Δ-9, Δ-10) which might be attributed to epitope recognition competition with the simultaneous priming of PreS1-specific T cells. Overall, this shows that active immunization is able to induce functional T cells to PreS1 and HDAg antigens and suggests that a broadly functional immunotherapy should contain both HDV genotypes 1 and 2 to ensure induction of specific T cells.

[0142] Similar experiments were performed with HLA-A2 restricted T cells purified from HLA-A2 transgenic HHD mice. IFNγ ELISpot of normal C57BL/6 (Figure 5A) and HLA-A2 HHD (Figure 5B) mice electroporated with a composition comprising Δ-4, along with naïve HLA-A2 HHD mice as control (Figure 5C), confirms immunogenicity in the transgenic mice, suggesting efficacy of the DNA compositions for treating humans.

Example 4: HBV/HDV DNA compositions induce immunogenic response in rabbits

[0143] Corresponding experiments described in Example 3 were also performed in rabbits (*Oryctolagus cuniculus*). New Zealand white rabbits were injected intramuscularly with a saline solution containing 900 μg of DNA compositions comprising either Δ-3 or Δ-4

and subjected to electroporation. Doses were administered at 0 and 4 weeks. After immunization, anti-PreS1 antibody titers in the rabbit sera were observed for both DNA compositions comprising Δ-3 or Δ-4, with Δ-4 being more effective (>10^3) (Figures 6A-B). Cross-reactivity of the rabbit antisera against HBV (sub-) types A1, A2, B, B2, C, D1, E1 and F using pools of 20-mer PreS1 peptides was also tested (Figure 6C). The fine specificity of the rabbit D4 anti-sera was determined using individually 20-mer PreS1 peptides of HBV types A1, A2, B, B2, C, D1, E1 and F (Figure 6D). This mapped the epitopes to PreS1 located to region 22-48 aa of genotype D1, as indicated by the higher reactivity, followed by lower reactivity to genotypes C, E1 and A1. This overlaps with the NTCP binding site and partly with previously identified epitopes recognized by neutralizing antibodies.

[0144] Table 2 summarizes the immunity effects of the ten DNA immunogenic compositions. DNA compositions comprising Δ-4 resulted in the greatest titer of anti-PreS1/anti-HBV antibodies in both mice and rabbits and are used in the prime/boost immunizations of the subsequent Examples. Δ-4 also shows the broadest reactivity to the different HBV genotypes. "n.d" denotes low or undetectable levels of antibody activity. "n/a" denotes that the experiment was not performed.

Table 2: HBV/HDV DNA vaccine screen (50 μg DNA im/EP)

Candidate	HDV genotype (Gt)	Anti-PreS1 titer in mice	Genotype cross-reactivity in mice	Anti-PreS1 titer in rabbits
Δ-1	Gt 1 and 2	1:2160	C, D, E	n/a
Δ-2	Gt 1 and 2	1:2160	A1, A2, B2, C, D, E	<1:60
Δ-3	Gt 1 and 2	1:2160-1:12960	D, E	1:360
Δ-4	Gt 1 and 2	1:12960	A-F	1:2560
Δ-5	Gt 1 and 2	n.d.	n.d.	n/a
Δ-6	Gt 1 and 2	n.d.	n.d.	n/a
Δ-7	Gt 1	1:2160	A-E	n/a
Δ-8	Gt 2	1:2160	C, D, E	n/a
Δ-9	Gt 1	n.d.	n.d.	n/a
Δ-10	Gt 2	n.d.	n.d.	n/a

Example 5: DNA prime/protein boost approach with HBV/HDV constructs improves immunogenic response in mice

[0145] DNA compositions comprising Δ-4 (SEQ ID NO: 18) and polypeptide compositions comprising Δ-7 (SEQ ID NO: 31) or Δ-8 (SEQ ID NO: 32) were used for a DNA prime/protein boost immunization approach to build adaptive immunity and induce antibody production against HBV and/or HDV *in vivo* (Figure 2).

[0146] C57BL/6 mice were immunized with (1) a DNA composition comprising Δ-4 (3 sequential doses of 50 μg DNA), (2) a polypeptide composition comprising Δ-7 (3 sequential does of 20 μg protein with alum adjuvant), or (3) a DNA composition comprising Δ-4 followed by a polypeptide composition comprising Δ-8 (2 doses of 50 μg DNA then 2 doses of 20 μg protein with alum). After administration of the compounds, purified white blood cells were tested for IFNγ production in response to HBV and HDV antigens by ELISpot (as described in Examples 1 and 2). Mice treated with (1) exhibited a commensurate response to hepatitis antigens (Figure 7A) observed in Example 3 and Figure 3B, but mice treated with the DNA prime/protein boost compositions of (3) resulted in a comparatively stronger immune cell response overall (Figure 7C). As Δ-8 includes sequences for the HDAg genotype 2 polypeptides, the assayed immune response is particularly improved against these antigens (Figure 7C, gtp 2-pool 5, 6, 7 and 8). Conversely, the protein-only approach of (2) using Δ-7 polypeptides fails to both elicit an equally effective immune response for both HBV and HDV antigens (Figure 7B). This demonstrates that this DNA prime/protein boost approach may be effective at inducing a robust immunogenic response greater than traditional protein or organism-based compositions for certain pathogens, including HBV and HDV.

[0147] Other DNA prime/protein boost combinations were also assessed in mice. Anti-PreS1 IgG titers in mice were measured after immunization with (1) a DNA-only composition comprising Δ-4 ("D4"), (2) protein-only compositions comprising Δ-7 ("D7-D7"), Δ-8 ("D8-D8"), Δ-9 ("D9-D9"), or Δ-10 ("D10-D10"), or (3) DNA-protein compositions comprising Δ-4 DNA with Δ-7 ("D4-D7"), Δ-8 ("D4-D8"), Δ-9 ("D4-D9"), or Δ-10 ("D4-D10") protein. Compositions were administered three times at weeks 0, 4, and 8, with either 50 μg DNA im/EP or 20 μg protein with alum administered for each dose. For DNA-protein compositions (3), 50 μg DNA im/EP was administered for the first dose at week 0, and 20 μg protein with alum was administered for the second and third doses at weeks 4 and 8. Anti-

PreS1 IgG titers in sera were assessed after 2 weeks (Figure 8A), 6 weeks (Figure 8B), and 10 weeks (Figure 8C) after the first dosage (i.e. 2 weeks after each dosage). DNA prime/protein boost composition D4-D7 results in superior anti-PreS1 titers after the completion of the dose administration schedule.

Example 6: DNA prime/protein boost approach with HBV/HDV constructs improves immunogenic response in rabbits

[0148] New Zealand white rabbits were immunized with (1) a DNA-only composition comprising Δ-4, (2) a protein-only composition comprising Δ-4, or (3) a DNA prime/protein boost composition comprising Δ-4 DNA and Δ-4 protein. Compositions were administered four times as weeks 0, 4, 8, and 12, with either 900 μg DNA im/EP or 300 μg protein with alum administered for each dose. For DNA-protein compositions (3), 900 μg DNA im/EP was administered for the first dose at week 0, and 300 μg protein with alum was administered for the second, third, and fourth doses at weeks 4, 8, and 12. Anti-PreS1 IgG titers in sera were assessed at weeks 0, 2, 10, and 14 (i.e. 2 weeks after each dosage) (Figure 9). Not only does the DNA prime/protein boost composition (3) result in greater overall titers compared to DNA-only (1) and protein-only (2) compositions, but also induces robust antibody production more rapidly, by week 2, relative to the protein-only composition.

Example 7: Adoptive transfer of sera or purified IgG from immunized animals protects humanized mice against HBV and HDV challenges

[0149] The ability of D4 induced antibodies to neutralize HBV infection *in vivo* was determined using human-liver chimeric $uPA^{+/+}$-SCID mouse model as described. Total IgG was purified from D4-immunized and non-immunized rabbits and were injected in $uPA^{+/+}$-SCID mice repopulated with human hepatocytes three days prior to HBV challenge. The D4-induced PreS1 IgG antibodies protected, or significantly delayed peak viremia in all challenged mice (Figure 10A). Out of three challenged mice, one was protected (weeks 1 to 3) whereas the other two developed serum levels of HBV $<10^4$ IU/ml up to a monthly screening and remained lower compared to the controls up to 8 weeks follow up. The control mice treated with IgG from a naïve rabbit all reached serum HBV DNA levels exceeding 10^8 IU/ml. There were no significant differences between the groups with respect to serum levels of alanine

transferase, asparagine transferase, alkaline phosphatase, or bilirubin (Figure 10B). In conclusion, passive immunization with D4-specific PreS1 IgG antibodies given as a single dose was able to prevent, or significantly delayed HBV infection *in vivo* in mice repopulated with human hepatocytes (Table 3). Importantly, the inoculum contains high levels of sub-viral particles SHBsAg showing that these antibodies indeed escape being blocked by SHBsAg. The PreS1 antibodies present at inoculation and during the first weeks clearly block infection, or the first rounds of infection, and limit the number of infected hepatocytes. This limits the viral spread and delay development of peak viremia.

Table 3: Adoptive transfer from DNA/protein vaccinated animals protects against HBV/HDV

Infection	Transfer source	Treatment	Number of mice	Absence of infection	Low level infection	High level infection
HBV	Purified rabbit IgG	Control	3	0	0	3
HBV	Purified rabbit IgG	D4 DNA	3	1	2	0
HBV/HDV	Whole mouse sera	Control	3	0	0	3
HBV/HDV	Whole mouse sera	D7 Protein /alum	2	2	0	0
HBV/HDV	Whole mouse sera	D4 DNA +D7/alum	3	3	0	0

Example 8: Challenge of HBV/HDV peptide constructs with different adjuvants

[0150] Mixtures of D-7 and D-8 peptides were assessed using different adjuvants. C57BL/6J mice were administered with 2 rounds of a 20 μg mixture of D-7 and D-8 peptides (10 μg each of D-7 and D-8) administered at week 0 and week 3 (Figure 11A). Peripheral blood samples were taken at week 2 (between the two rounds) to determine end titers for HBV and HDV reactivity by ELISA (Figure 11A and 11B), and splenocytes were isolated for HBV and HDV reactivity by ELISpot (Figure 11C-D) at week 5. Peptide compositions were administered subcutaneously with QS-21, MF59, and alum adjuvants. Naïve mice and mice administered D-4 DNA plasmid by intramuscular electroporation were used as controls. IFNγ

ELISpot was performed as described above using pools of HDAg peptides, PreS1A and PreS1B peptides, with OVA peptides and Concanavalin A as controls (Figures 11C-D). Compositions administered with QS-21 adjuvant exhibited elevated HDAg reactivity compared to the other adjuvants. 5 mice per group were tested.

Example 9: Comparison of exemplary HBV/HDV DNA and/or peptide constructs

[0151] A comparison of immunogenicity for 1) a mixture of D-7 and D-8 peptide only, 2) D-7+D-8 fusion peptide only, 3) D-4 DNA prime and a mixture of D-7 and D-8 peptide boost were tested, with D-4 DNA only and naïve conditions as controls. Mice were administered with either 20 μg of the D-7+D-8 fusion protein or 10 μg each of D-7 and D-8 peptide in the mixed conditions with QS-21 adjuvant, subcutaneously at the tail base in a volume of 100 μL. 2 rounds of administration was performed at weeks 0 and 4. D-4 DNA control was administered at 50 μg intramuscular in 50 μL PBS with electroporation. At week 6 (following two rounds of administration), T cell response to PreS1 and HDV antigen genotypes 1 and 2 were determined by IFNγ ELISpot (Figure 12A). In addition, at weeks 2 (following one round of administration) and 6 weeks (following two rounds of administration), antibody levels to PreS1A (Figure 12B-C) and PreS1B (Figure 12D) consensus peptides were assessed. The greatest HBV and HDV reactivity are observed in the DNA prime, peptide boost condition.

Example 10: DNA or protein prime with DNA or protein boost immunization against HBV and/or HDV in human clinical trials

[0152] The following example describes embodiments of using an immunogenic composition or product combination, optionally comprised of a nucleic acid component and a polypeptide component, used to treat or prevent viral infections caused by viruses such as HBV and HDV.

[0153] The DNA prime/protein boost compositions as described in Example 5 are administered to human patients enterally, orally, intranasally, parenterally, subcutaneously, intramuscularly, intradermally, or intravenously. These human patients may be currently infected with HBV and/or HDV, previously infected with HBV and/or HDV, at risk of being infected with HBV and/or HDV, or uninfected with HBV and/or HDV.

[0154] The DNA prime doses are administered first, at an amount of 1, 10, 100, 1000 ng, or 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 μg, or 1, 10, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 mg, or any amount within a range defined by any two of the aforementioned amounts, or any other amount appropriate for optimal efficacy in humans. After the first DNA prime dose, 1, 2, 3, 4, or 5 additional DNA prime doses can be administered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks or any time within a range defined by any two of the aforementioned times after administration of the previous DNA prime dose, e.g., within 1-48 days or 1-48 weeks. The protein boost doses are administered following the DNA prime doses, at an amount of 1, 10, 100, 1000 ng, or 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 μg, or 1, 10, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 mg, or any amount within a range defined by any two of the aforementioned amounts, or any other amount appropriate for optimal efficacy in humans. The first protein boost dose is administered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks or any time within a range defined by any two of the aforementioned times after administration of the final DNA prime dose. After the first protein boost dose, 1, 2, 3, 4, or 5 additional protein boost doses can be administered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks or any time within a range defined by any two of the aforementioned times after administration of the previous protein boost dose.

[0155] Patients will be monitored for successful response against HBV and/or HDV, for example, production of anti-HBV, anti-HDV, anti-PreS1, or anti-HDAg antibodies in sera, rapid activation of T cells and other immune cells when exposed to HBV and/or HDV antigens, and protection against future HBV and/or HDV infections.

[0156] In patients currently infected, previously infected, or at risk for infection with HBV and/or HDV, administration of the DNA prime/protein boost compositions may be performed in conjunction with antiviral therapy. Potential antiviral therapy therapeutics that have been shown to be effective against HBV or HDV include but are not limited to entecavir, tenofovir, lamivudine, adefovir, telbivudine, emtricitabine, interferon-α, pegylated interferon-α, or interferon alfa-2b, or any combination thereof. Patients will be monitored for side effects such as dizziness, nausea, diarrhea, depression, insomnia, headaches, itching, rashes, fevers, or other known side effects of the provided antiviral therapeutics.

[0157] In at least some of the previously described embodiments, one or more elements used in an embodiment can interchangeably be used in another embodiment unless such a replacement is not technically feasible. It will be appreciated by those skilled in the art that various other omissions, additions and modifications may be made to the methods and structures described above without departing from the scope of the claimed subject matter. All such modifications and changes are intended to fall within the scope of the subject matter, as defined by the appended claims.

[0158] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0159] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least

one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., " a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0160] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0161] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible sub-ranges and combinations of sub-ranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like include the number recited and refer to ranges which can be subsequently broken down into sub-ranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 articles refers to groups having 1, 2, or 3 articles. Similarly, a group having 1-5 articles refers to groups having 1, 2, 3, 4, or 5 articles, and so forth.

[0162] While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and

embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

[0163] All references cited herein, including but not limited to published and unpublished applications, patents, and literature references, are incorporated herein by reference in their entirety and are hereby made a part of this specification. To the extent publications and patents or patent applications incorporated by reference contradict the disclosure contained in the specification, the specification is intended to supersede and/or take precedence over any such contradictory material.

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WHAT IS CLAIMED IS:

1. An immunogenic composition or product combination comprising:

(a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg) and at least one nucleic acid sequence encoding PreS1; and

(b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence.

2. The immunogenic composition or product combination of claim 1, wherein the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4, or any combination thereof.

3. The immunogenic composition or product combination of claim 1 or 2, wherein the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both.

4. The immunogenic composition or product combination of any one of claims 1-3, wherein the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence.

5. The immunogenic composition or product combination of claim 4, further comprising at least one nucleic acid sequence encoding an autocatalytic peptide cleavage site, wherein the grouped HDAg and PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site.

6. The immunogenic composition or product combination of claim 5, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea*

asigna virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus.

7. The immunogenic composition or product combination of claim 5 or 6, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13.

8. The immunogenic composition or product combination of any one of claims 1-7, wherein the nucleic acid is codon optimized for expression in a human.

9. The immunogenic composition or product combination of any one of claims 1-8, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36.

10. The immunogenic composition or product combination of any one of claims 1-9, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 18, or SEQ ID NO: 35-36.

11. The immunogenic composition or product combination of any one of claims 1-10, wherein the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof.

12. The immunogenic composition or product combination of any one of claims 1-11, wherein the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both.

13. The immunogenic composition or product combination of any one of claims 1-12, wherein the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence.

14. The immunogenic composition or product combination of any one of claims 1-13, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37.

15. The immunogenic composition or product combination of any of claims 1-14, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37.

16. The immunogenic composition or product combination of any one of claims 1-15, wherein the polypeptide is recombinantly expressed.

17. The immunogenic composition or product combination of claim 16, wherein the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system.

18. The immunogenic composition or product combination of any one of claims 1-17, further comprising an adjuvant.

19. The immunogenic composition or product combination of claim 18, wherein the adjuvant is alum, QS-21 or MF59, or any combination thereof.

20. The immunogenic composition or product combination of any one of claims 1-19, wherein the nucleic acid comprises DNA.

21. The immunogenic composition or product combination of any one of claims 1-20, wherein the nucleic acid is provided in a recombinant vector.

22. A method of generating an immune response in a subject using the immunogenic composition or product combination set forth in any one of claims 1-21, comprising:

administering to the subject at least one prime dose comprising the nucleic acid; and

administering to the subject at least one boost dose comprising the polypeptide.

23. The method of claim 22, wherein the at least one boost dose further comprises an adjuvant.

24. The method of claim 23, wherein the adjuvant is alum, QS-21, or MF59, or any combination thereof.

25. The method of any one of claims 22-24, wherein the at least one boost dose is administered at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 36, or 48 days or weeks after the at least one prime dose is administered or within a range of time defined by any two of the aforementioned time points e.g., within 1-48 days or 1-48 weeks.

26. The method of any one of claims 22-25, wherein the administration is provided enterally, orally, intranasally, parenterally, subcutaneously, intramuscularly, intradermally, or intravenously or any combination thereof.

27. The method of any one of claims 22-26, wherein the administration is performed in conjunction with an antiviral therapy.

28. The method of claim 27, wherein the antiviral therapy comprises administration of entecavir, tenofovir, lamivudine, adefovir, telbivudine, emtricitabine, interferon-α, pegylated interferon-α, or interferon alfa-2b, or any combination thereof.

29. An immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D, comprising:

(a) a nucleic acid comprising at least one nucleic acid sequence encoding hepatitis D antigen (HDAg), and at least one nucleic acid sequence encoding PreS1; and

(b) a polypeptide comprising at least one HDAg polypeptide sequence and at least one PreS1 polypeptide sequence.

30. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 29, wherein the at least one nucleic acid sequence encoding HDAg comprises SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 4, or any combination thereof.

31. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 29 or 30, wherein the at least one nucleic acid sequence encoding PreS1 comprises SEQ ID NO: 9 or SEQ ID NO: 10 or both.

32. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-31, wherein the nucleic acid is configured such that each HDAg nucleic acid sequence is grouped with a PreS1 nucleic acid sequence, and wherein the PreS1 nucleic acid sequence is immediately downstream of the HDAg nucleic acid sequence.

33. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 32, further comprising at least one nucleic acid sequence encoding an autocatalytic peptide cleavage site, wherein the grouped HDAg and PreS1 nucleic acid sequences are separated by the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site.

34. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 33, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises a nucleic acid sequence selected from the group consisting of porcine teschovirus-1 2A (P2A), foot-and-mouth disease virus 2A (F2A), equine rhinitis A virus (ERAV) 2A (E2A) and *Thosea asigna* virus 2A (T2A) nucleic acid, and wherein each encoded autocatalytic peptide cleavage site may optionally include a GSG (glycine-serine-glycine) motif at its N-terminus.

35. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 33 or 34, wherein the at least one nucleic acid sequence encoding the autocatalytic peptide cleavage site comprises SEQ ID NO: 13.

36. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-35, wherein the nucleic acid is codon optimized for expression in a human.

37. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-36, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 15-24 or 35-36.

38. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-37, wherein the nucleic acid comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to SEQ ID NO: 18, or SEQ ID NO: 35-36.

39. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-38, wherein the at least one HDAg polypeptide comprises SEQ ID NO: 5, SEQ ID NO: 6, SEQ ID NO: 7 or SEQ ID NO: 8 or any combination thereof.

40. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-39, wherein the at least one PreS1 polypeptide sequence comprises SEQ ID NO: 11 or SEQ ID NO: 12 or both.

41. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-40, wherein the at least one PreS1 polypeptide sequence is downstream of the at least one HDAg polypeptide sequence.

42. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-41, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 25-34 or 37.

43. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any of claims 29-42, wherein the polypeptide comprises a sequence having at least 80%, 85%, 90%, 95%, 99%, or 100% homology to the sequence of SEQ ID NO: 29, 31, 32, or 37.

44. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-43, wherein the polypeptide is recombinantly expressed.

45. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 44, wherein the polypeptide is recombinantly expressed in a mammalian, bacterial, yeast, insect, or cell-free system.

46. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-45, further comprising an adjuvant.

47. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of claim 46, wherein the adjuvant is alum, QS-21 or MF59, or any combination thereof.

48. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-47, wherein the nucleic acid comprises DNA.

49. The immunogenic composition or product combination for use in the treatment or inhibition of hepatitis B or hepatitis D of any one of claims 29-48, wherein the nucleic acid is provided in a recombinant vector.

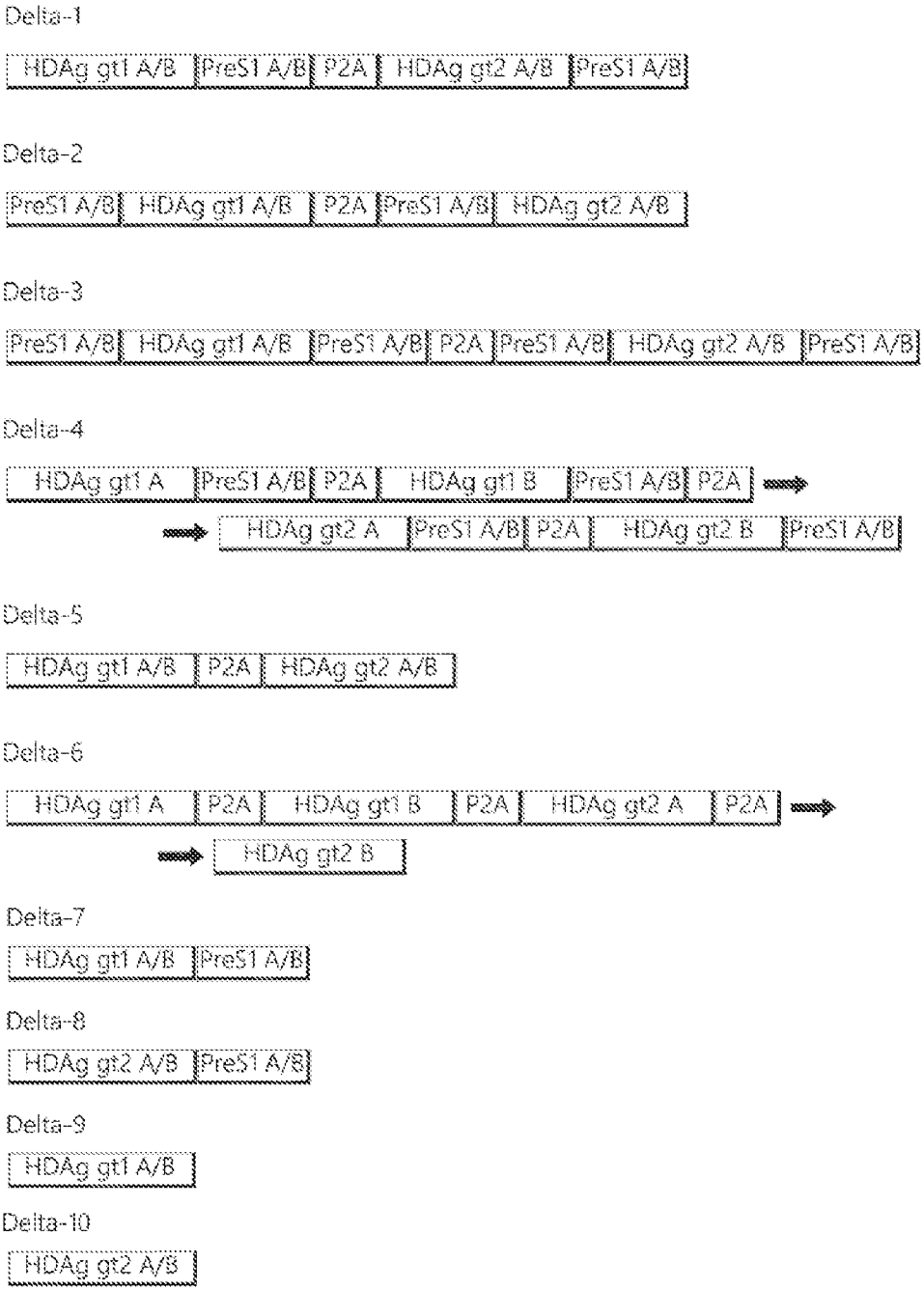

Delta-1
HDAg gt1 A/B
PreS1 A/B
P2A
HDAg gt2 A/B
PreS1 A/B
Delta-2
PreS1 A/B
HDAg gt1 A/B
P2A
PreS1 A/B
HDAg gt2 A/B
Delta-3
PreS1 A/B
HDAg gt1 A/B
PreS1 A/B
P2A
PreS1 A/B
HDAg gt2 A/B
PreS1 A/B
Delta-4
HDAg gt1 A
PreS1 A/B
P2A
HDAg gt1 B
PreS1 A/B
P2A
HDAg gt2 A
PreS1 A/B
P2A
HDAg gt2 B
PreS1 A/B
Delta-5
HDAg gt1 A/B
P2A
HDAg gt2 A/B
Delta-6
HDAg gt1 A
P2A
HDAg gt1 B
P2A
HDAg gt2 A
P2A
HDAg gt2 B
Delta-7
HDAg gt1 A/B
PreS1 A/B
Delta-8
HDAg gt2 A/B
PreS1 A/B
Delta-9
HDAg gt1 A/B
Delta-10
HDAg gt2 A/B

FIGURE 1A

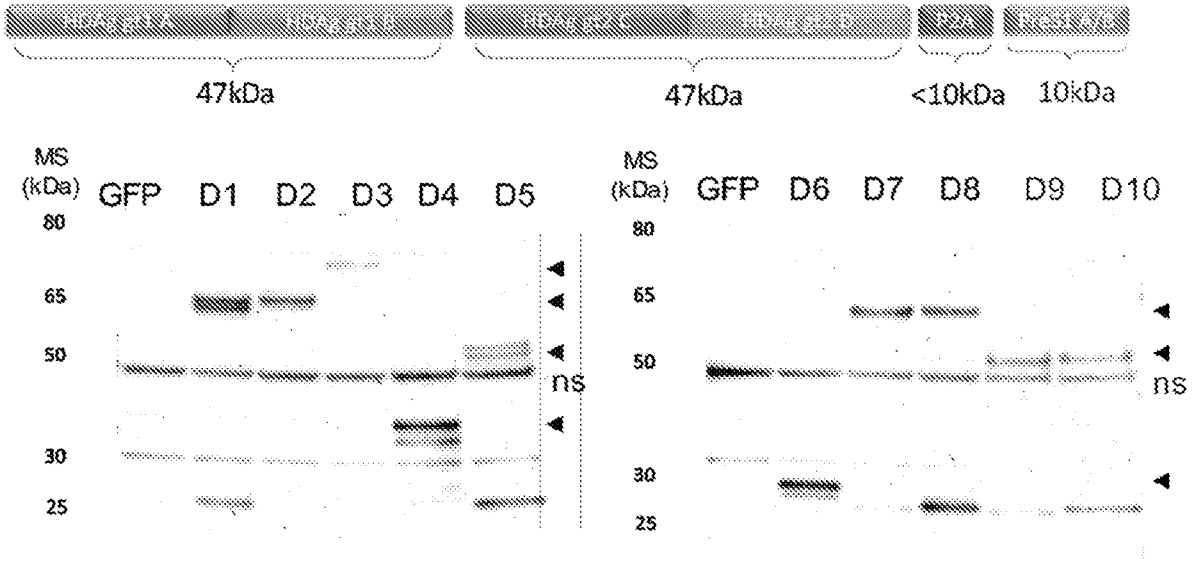

47kDa
47kDa
<10kDa
10kDa
MS (kDa)
GFP
D1
D2
D3
D4
D5
80
65
50
30
25
ns
MS (kDa)
GFP
D6
D7
D8
D9
D10
80
65
50
30
25
ns

FIGURE 1B

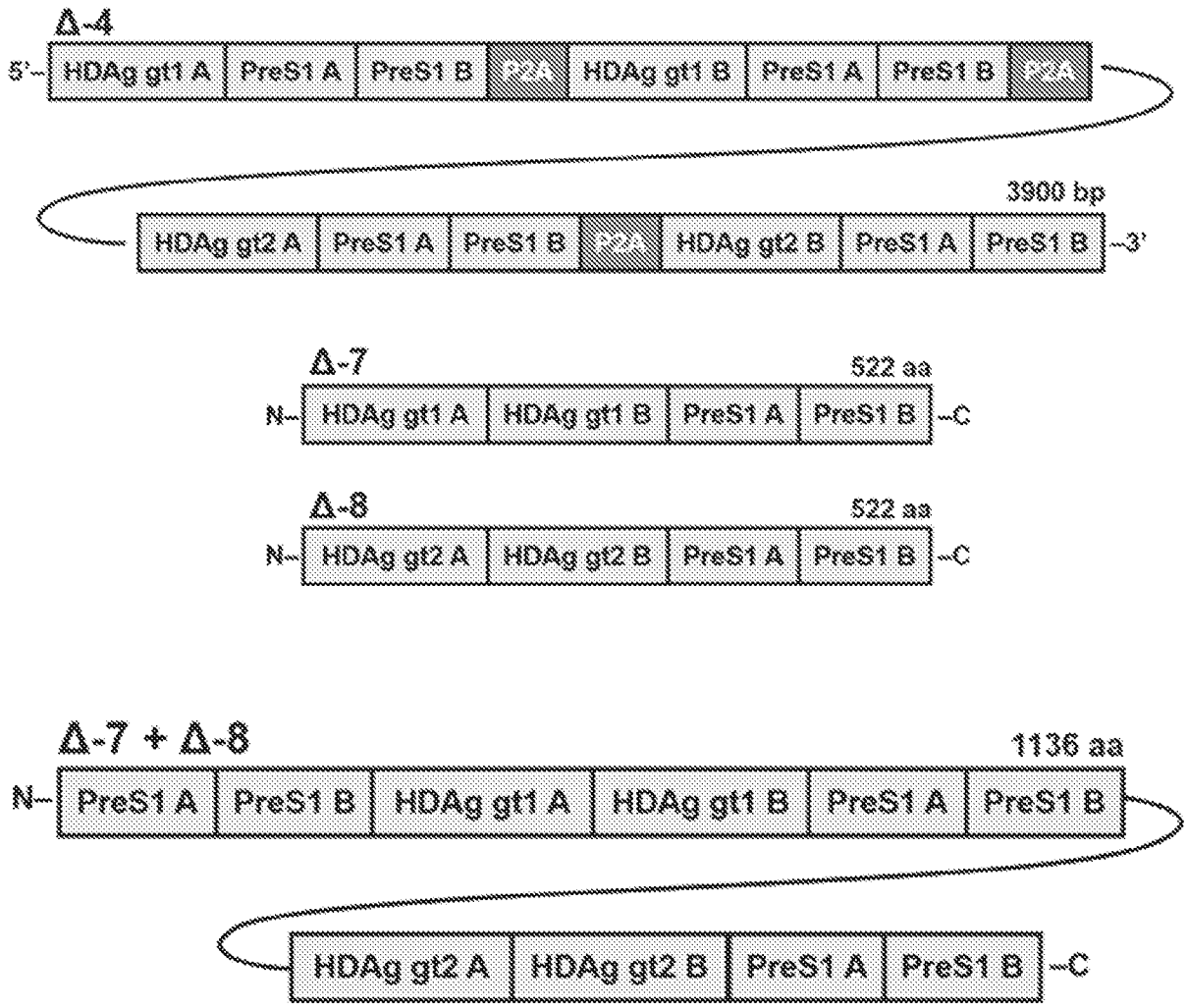

Δ-4
5'
HDAg gt1 A
PreS1 A
PreS1 B
P2A
HDAg gt1 B
PreS1 A
PreS1 B
P2A
3900 bp
HDAg gt2 A
PreS1 A
PreS1 B
P2A
HDAg gt2 B
PreS1 A
PreS1 B
3'
Δ-7
522 aa
N
HDAg gt1 A
HDAg gt1 B
PreS1 A
PreS1 B
C
Δ-8
522 aa
N
HDAg gt2 A
HDAg gt2 B
PreS1 A
PreS1 B
C
Δ-7 + Δ-8
1136 aa
N
PreS1 A
PreS1 B
HDAg gt1 A
HDAg gt1 B
PreS1 A
PreS1 B
HDAg gt2 A
HDAg gt2 B
PreS1 A
PreS1 B
C

FIGURE 2

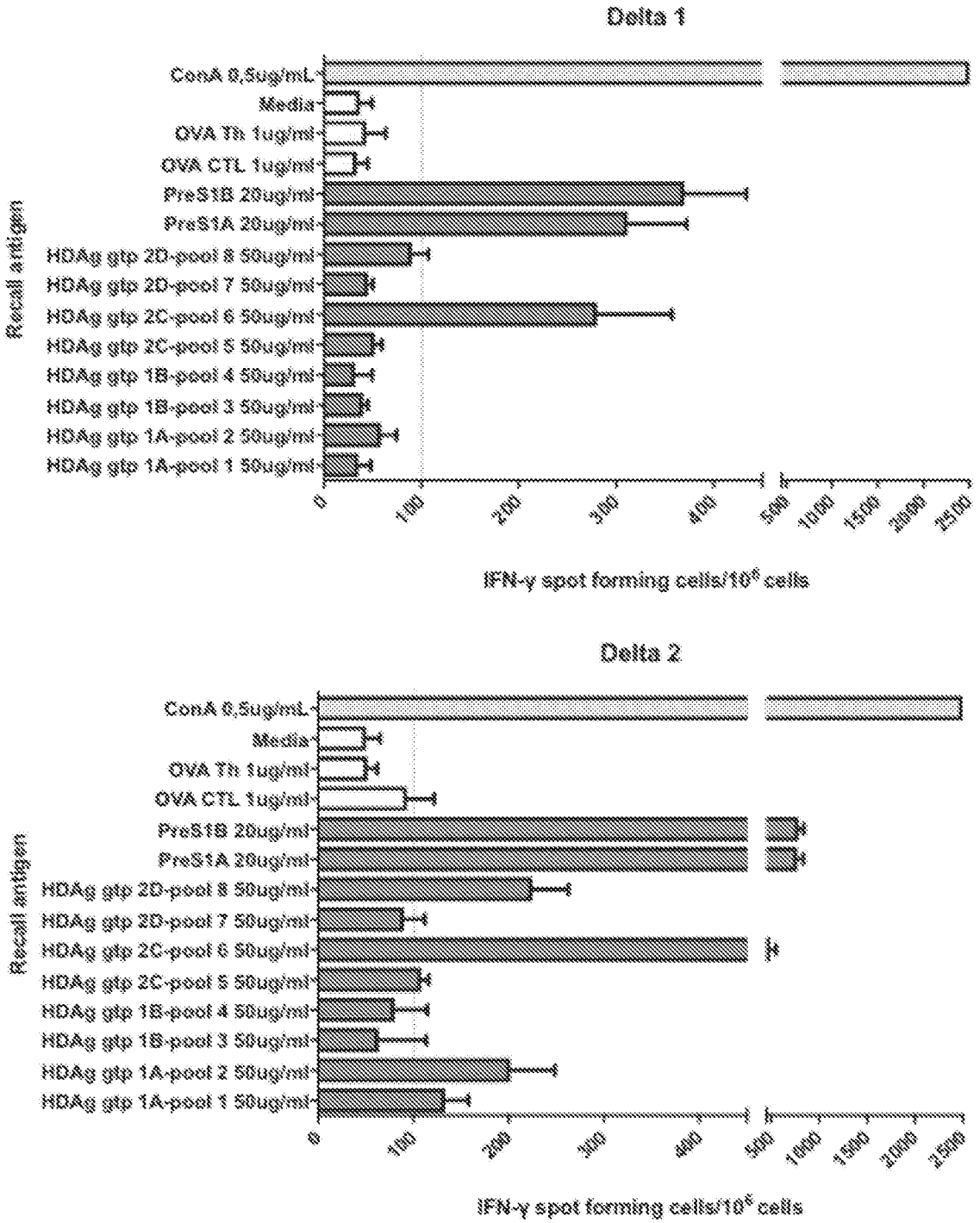

Delta 1
ConA 0,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells
Delta 2
ConA 0,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 3A

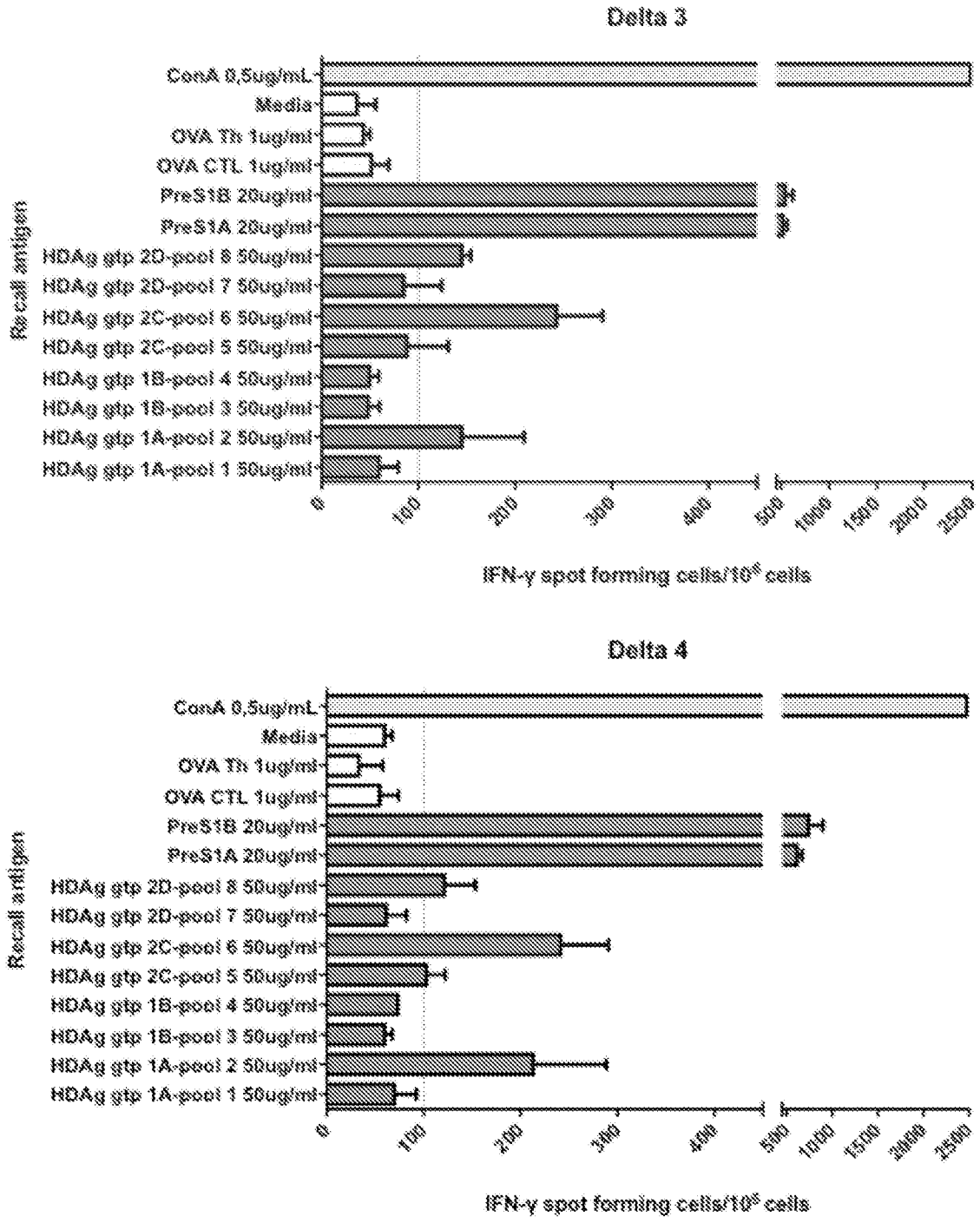

Delta 3
ConA 8,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells
Delta 4
ConA 8,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 3B

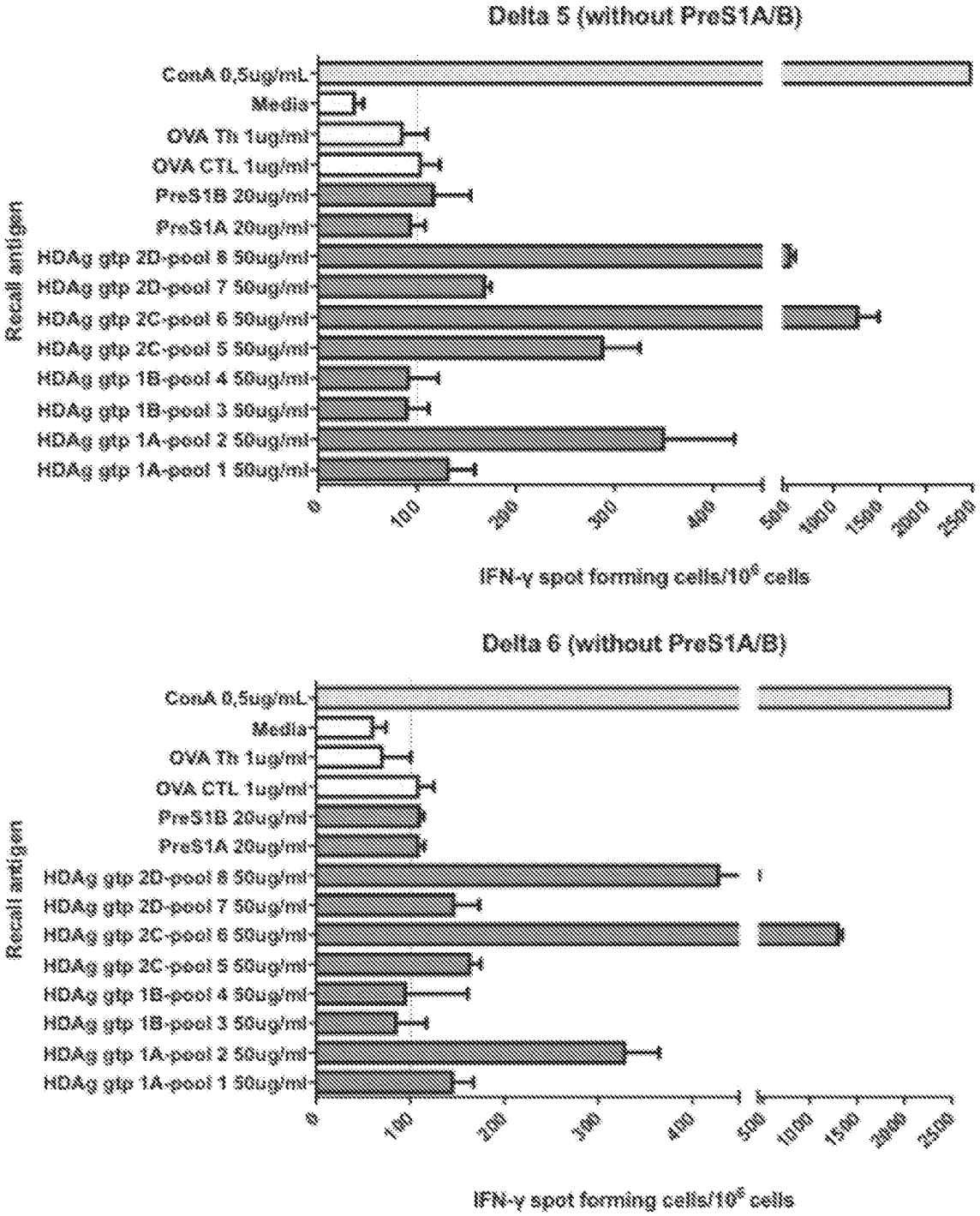

Delta 5 (without PreS1A/B)
ConA 8,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells
Delta 6 (without PreS1A/B)
ConA 8,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 3C

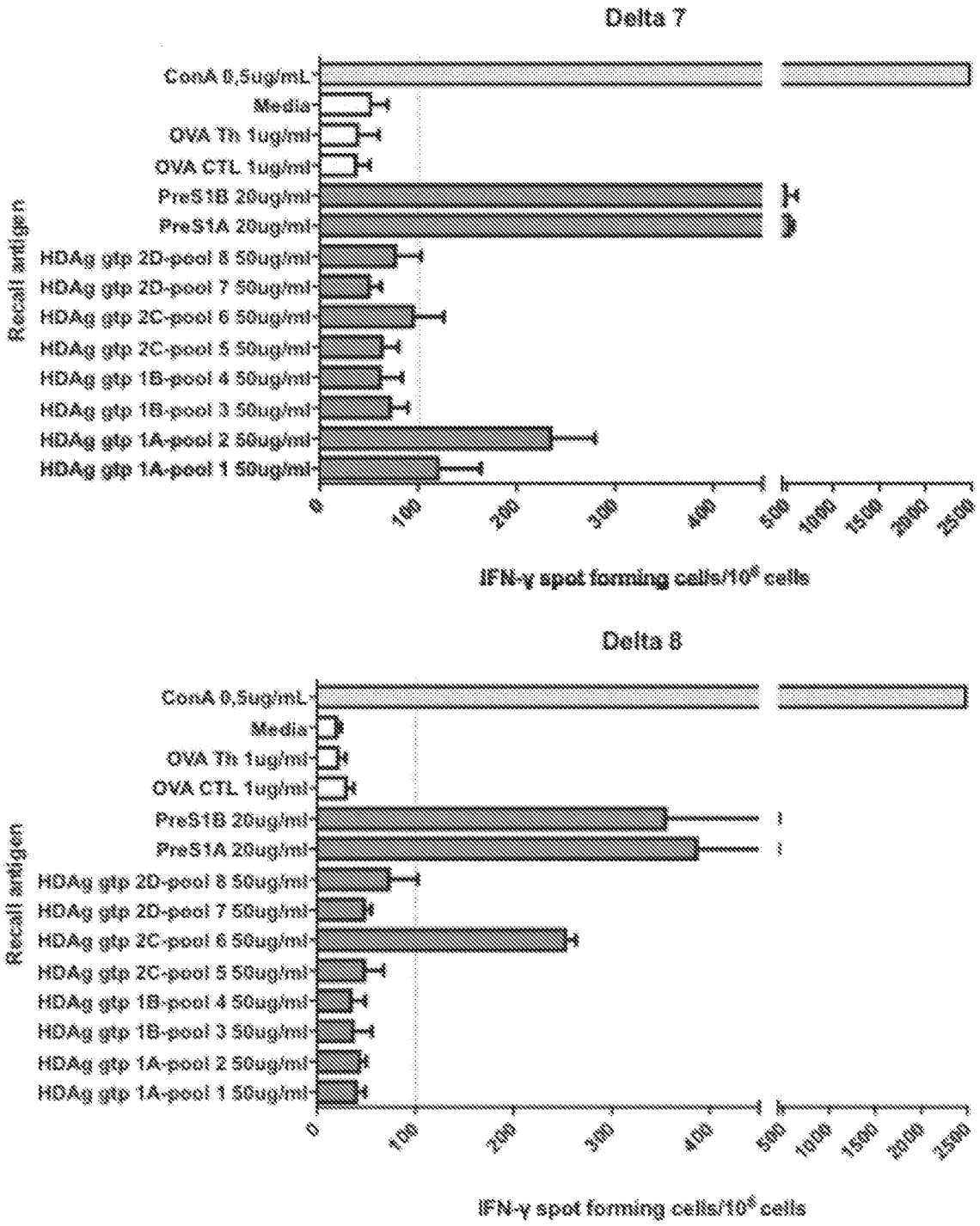

Delta 7
ConA 6,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells
Delta 8
ConA 6,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 3D

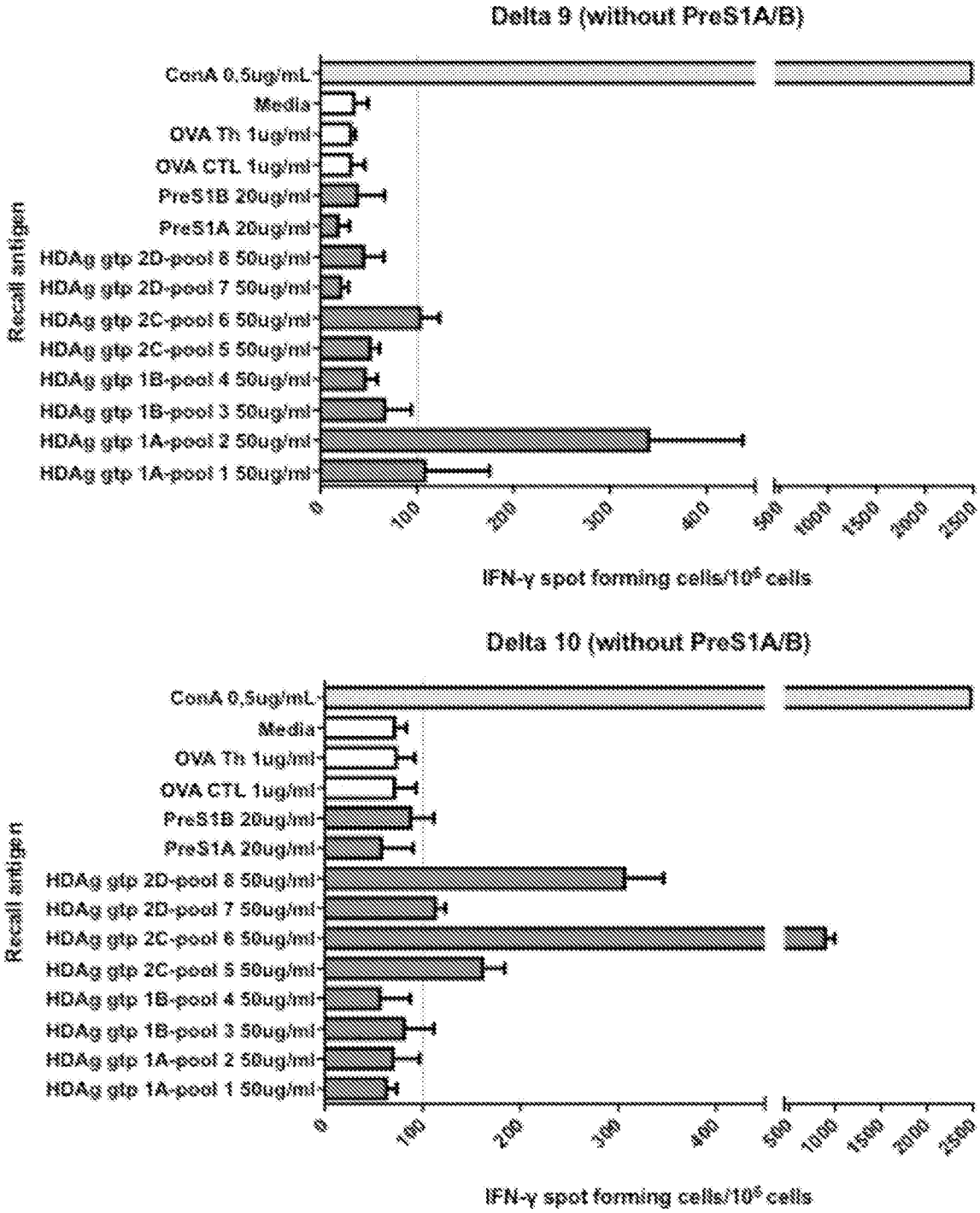

Delta 9 (without PreS1A/B)
ConA 0.5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells
Delta 10 (without PreS1A/B)
ConA 0.5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 3E

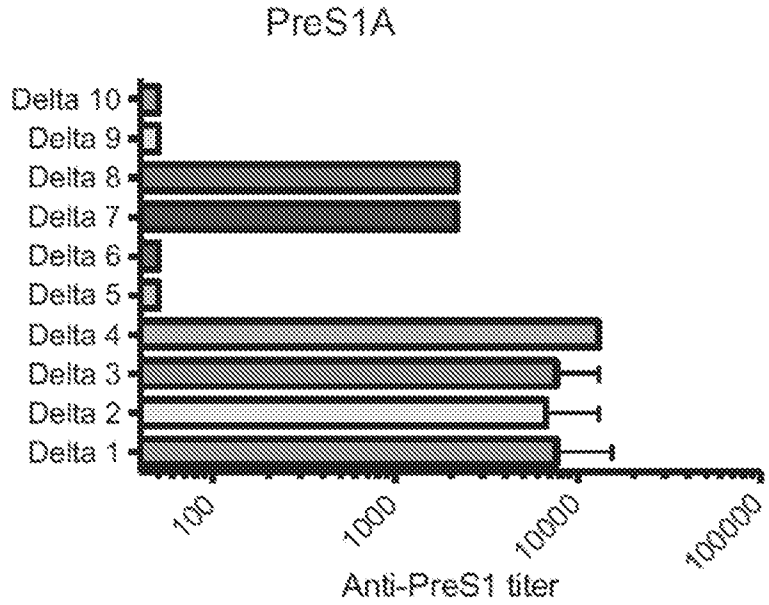


FIGURE 4A

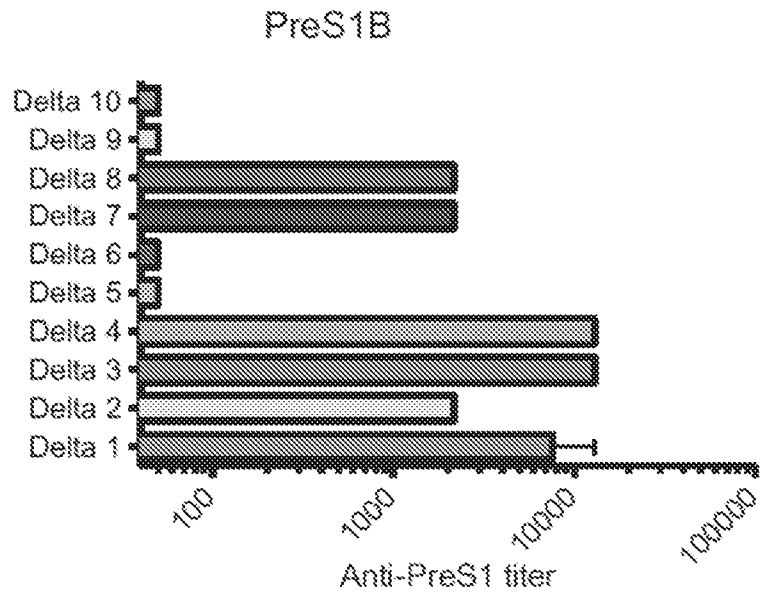


FIGURE 4B

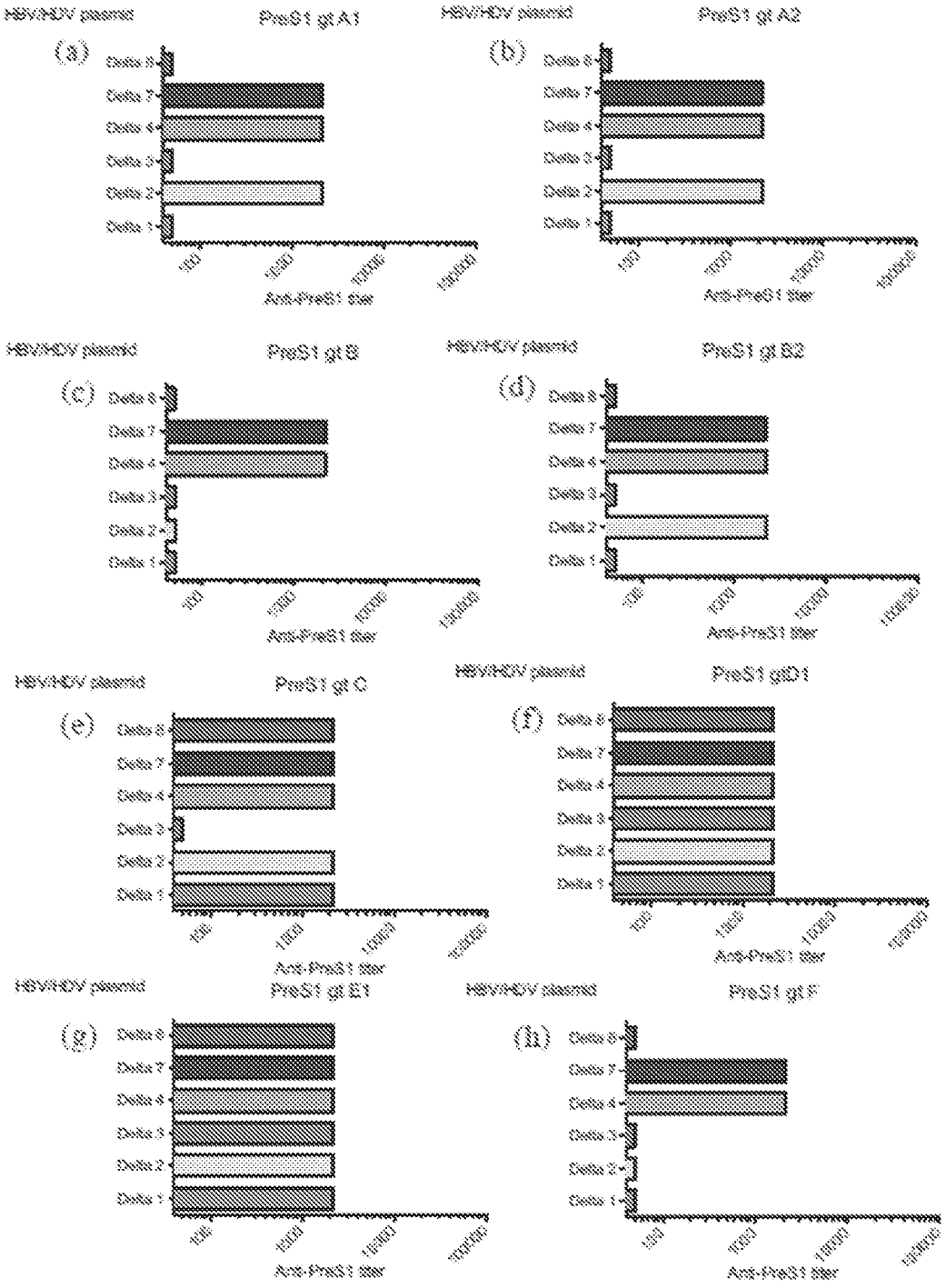

HBV/HDV plasmid
PreS1 gt A1
(a)
HBV/HDV plasmid
PreS1 gt A2
(b)
HBV/HDV plasmid
PreS1 gt B
(c)
HBV/HDV plasmid
PreS1 gt B2
(d)
HBV/HDV plasmid
PreS1 gt C
(e)
HBV/HDV plasmid
PreS1 gtD1
(f)
HBV/HDV plasmid
PreS1 gt E1
(g)
HBV/HDV plasmid
PreS1 gt F
(h)
Anti-PreS1 titer

FIGURE 4C

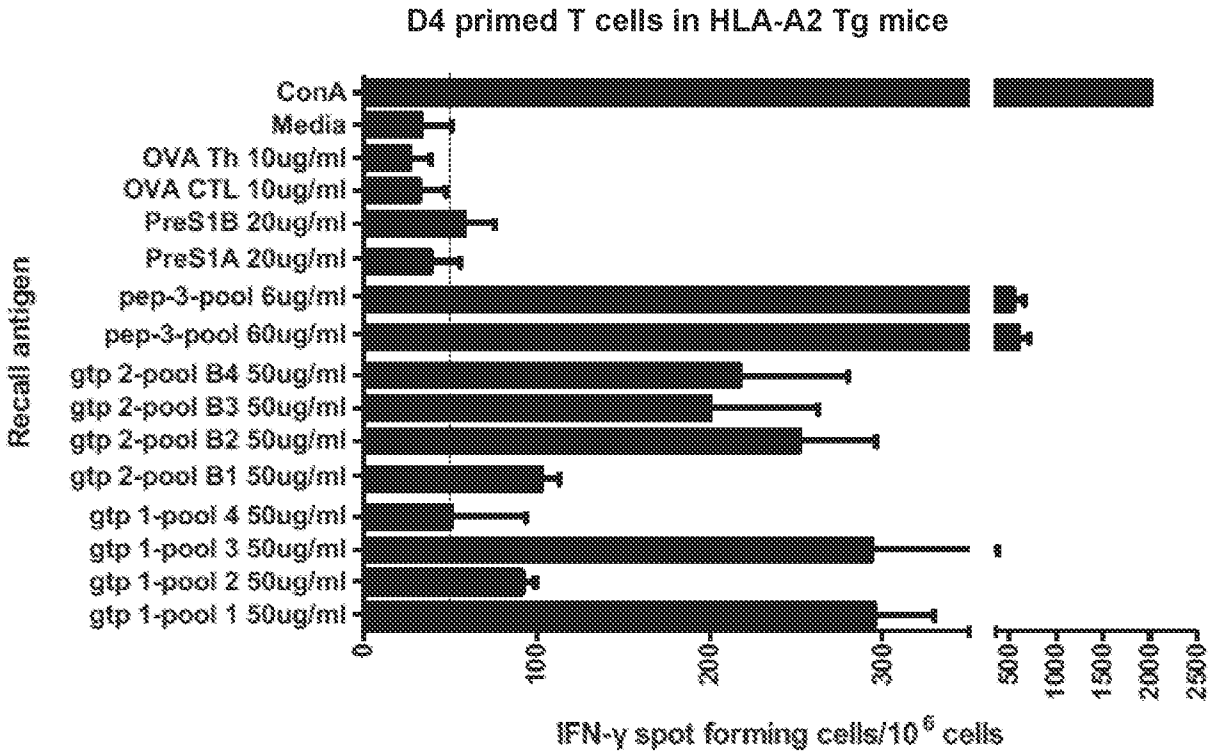

D4 primed T cells in HLA-A2 Tg mice
ConA
Media
OVA Th 10ug/ml
OVA CTL 10ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
pep-3-pool 6ug/ml
pep-3-pool 60ug/ml
gtp 2-pool B4 50ug/ml
gtp 2-pool B3 50ug/ml
gtp 2-pool B2 50ug/ml
gtp 2-pool B1 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
Recall antigen
0
100
200
300
500
1000
1500
2000
2500
IFN-γ spot forming cells/10^6 cells

FIGURE 5A

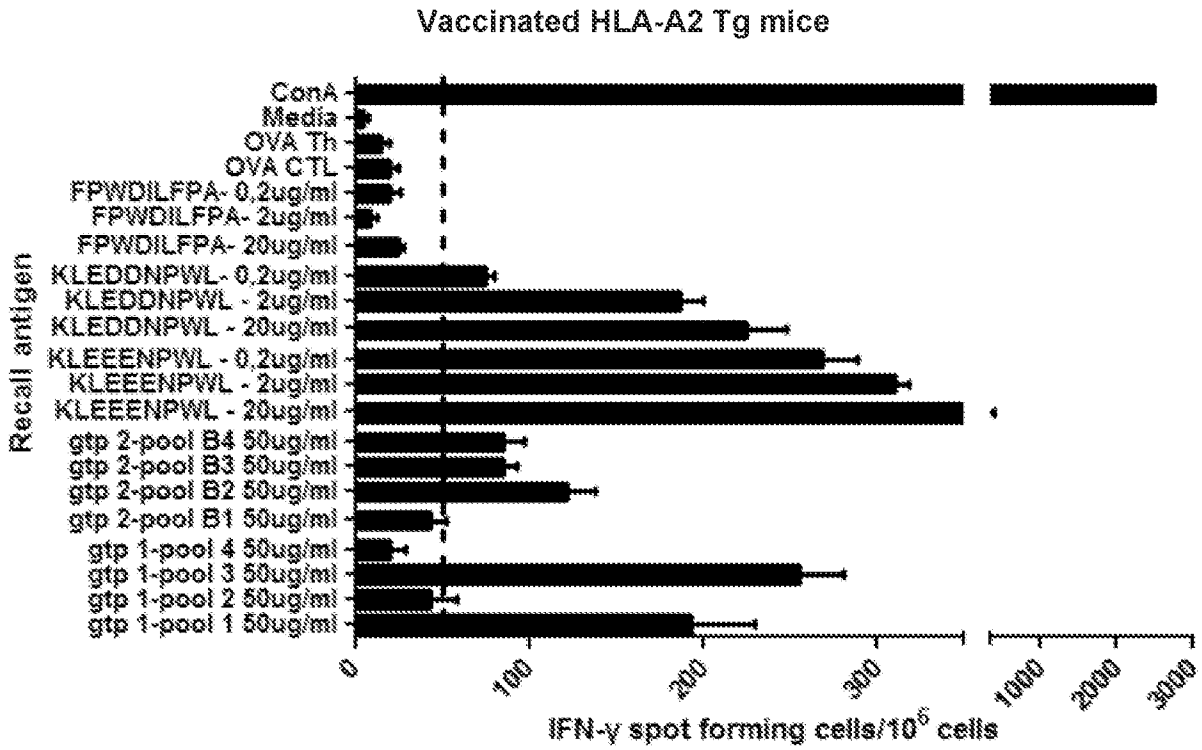

Vaccinated HLA-A2 Tg mice
Recall antigen
ConA
Media
OVA Th
OVA CTL
FPWDILFPA- 0.2ug/ml
FPWDILFPA- 2ug/ml
FPWDILFPA- 20ug/ml
KLEDDNPWL- 0.2ug/ml
KLEDDNPWL - 2ug/ml
KLEDDNPWL - 20ug/ml
KLEEENPWL - 0.2ug/ml
KLEEENPWL - 2ug/ml
KLEEENPWL - 20ug/ml
gtp 2-pool B4 50ug/ml
gtp 2-pool B3 50ug/ml
gtp 2-pool B2 50ug/ml
gtp 2-pool B1 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
0
100
200
300
1000
2000
3000
IFN-γ spot forming cells/10^6 cells

FIGURE 5B

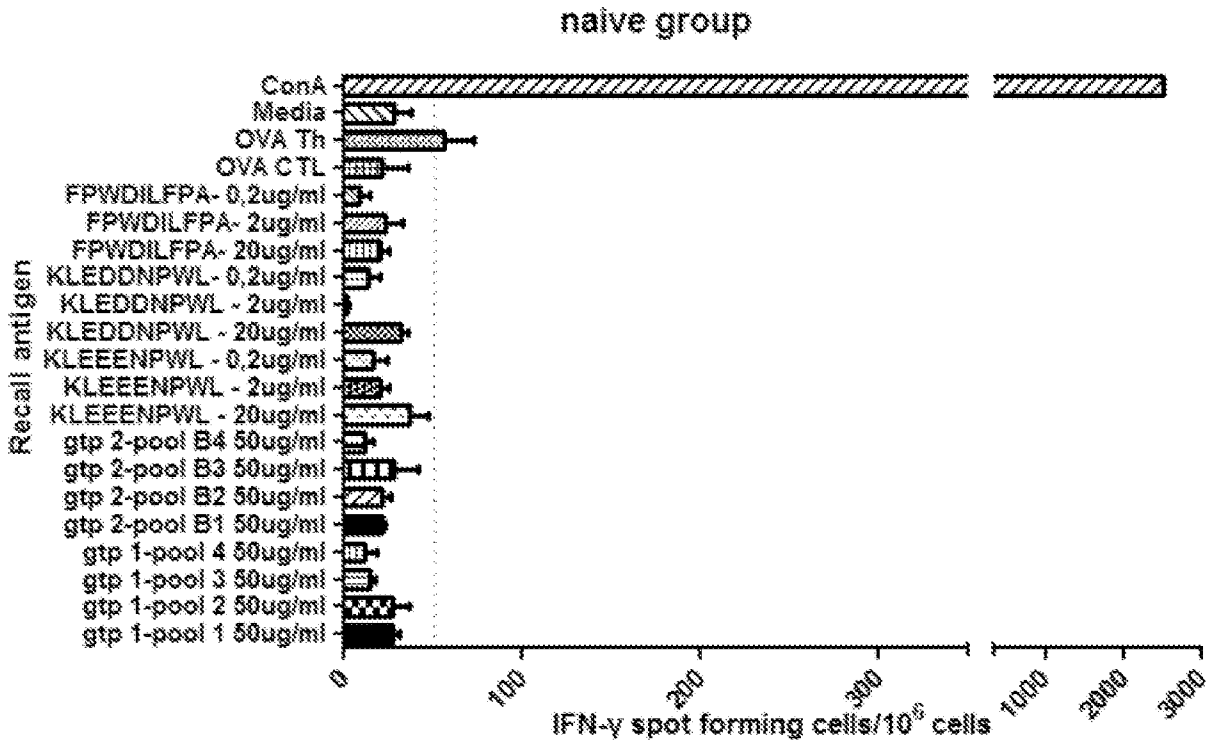

naive group
ConA
Media
OVA Th
OVA CTL
FPWDILFPA- 0.2ug/ml
FPWDILFPA- 2ug/ml
FPWDILFPA- 20ug/ml
KLEDDNPWL- 0.2ug/ml
KLEDDNPWL - 2ug/ml
KLEDDNPWL - 20ug/ml
KLEEENPWL - 0.2ug/ml
KLEEENPWL - 2ug/ml
KLEEENPWL - 20ug/ml
gtp 2-pool B4 50ug/ml
gtp 2-pool B3 50ug/ml
gtp 2-pool B2 50ug/ml
gtp 2-pool B1 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
Recall antigen
0
100
200
300
1000
2000
3000
IFN-γ spot forming cells/10^6 cells

FIGURE 5C

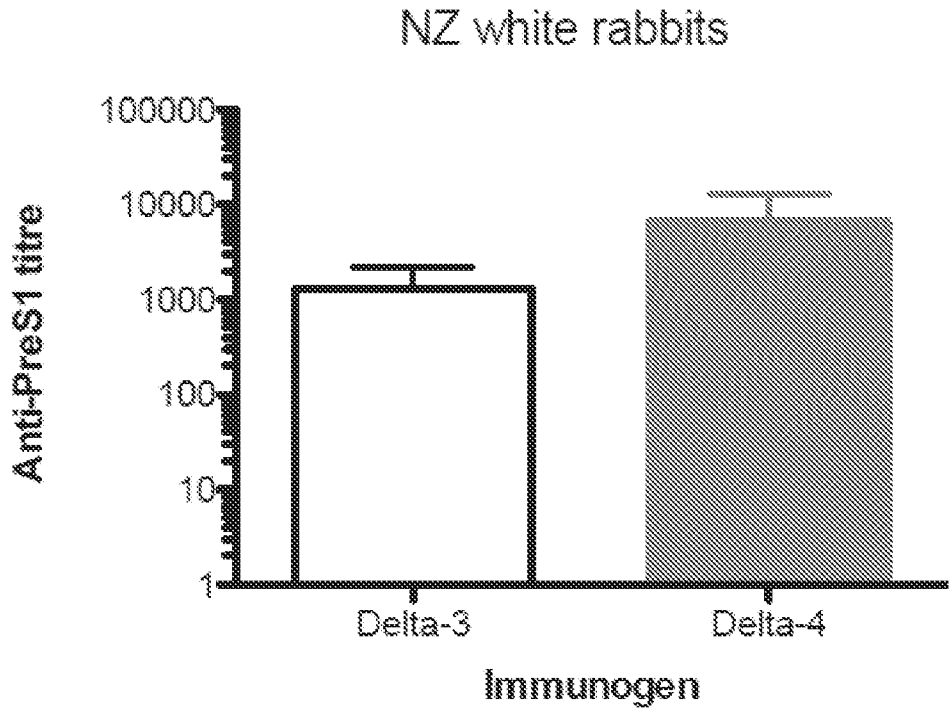


FIGURE 6A

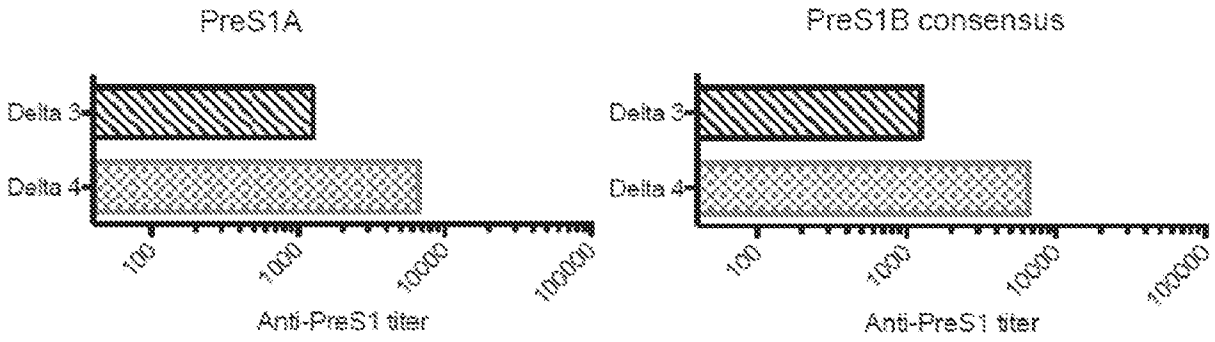


FIGURE 6B

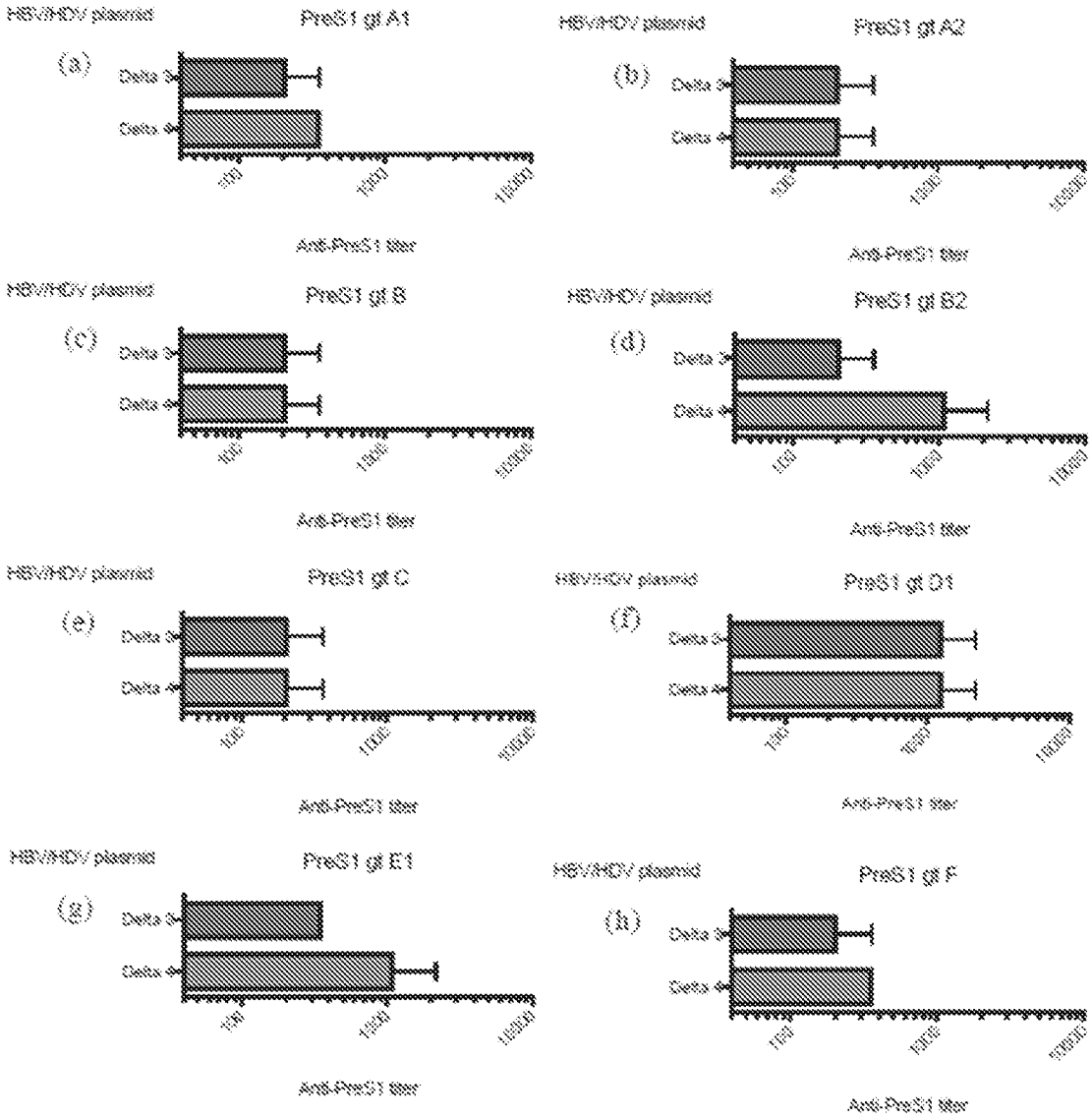
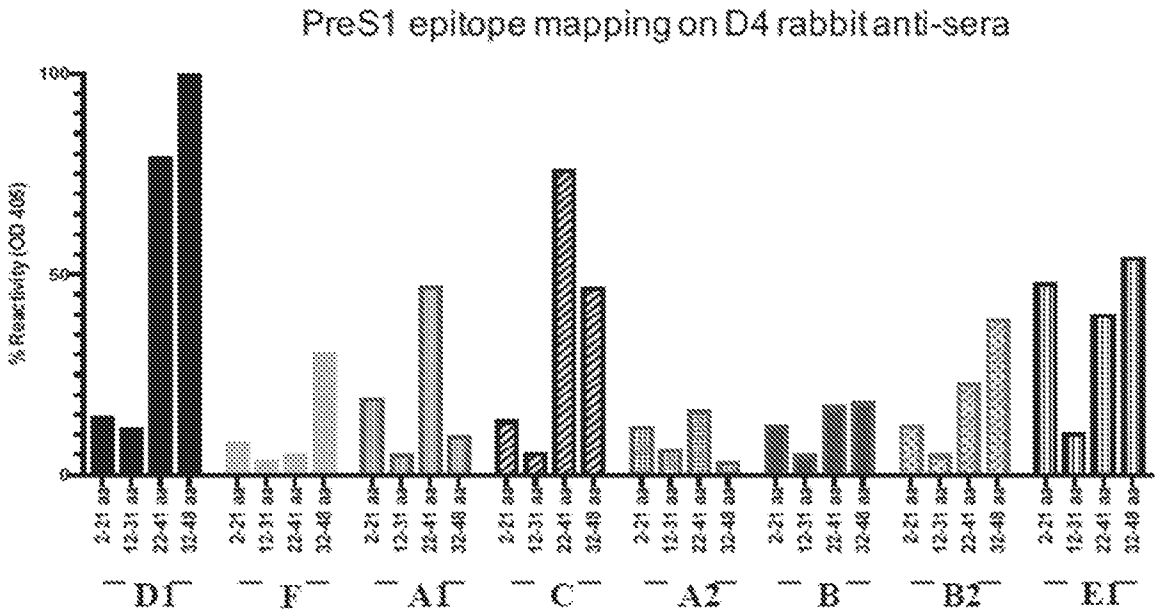

HBV/HDV plasmid
PreS1 gt A1
(a)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt A2
(b)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt B
(c)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt B2
(d)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt C
(e)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt D1
(f)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt E1
(g)
Delta
Delta
Anti-PreS1 titer
HBV/HDV plasmid
PreS1 gt F
(h)
Delta
Delta
Anti-PreS1 titer

FIGURE 6C


PreS1 epitope mapping on D4 rabbit anti-sera
% Reactivity (OD 405)
100
50
0
2-21
12-31
22-41
32-48
D1
F
A1
C
A2
B
B2
E1

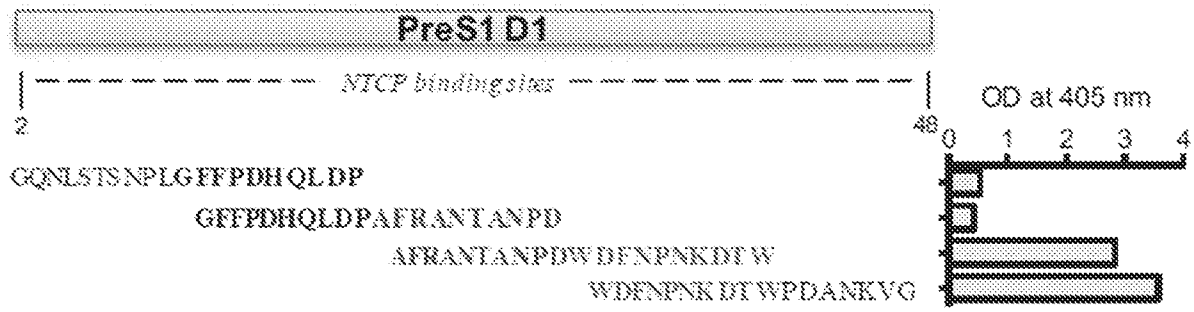

PreS1 D1
NTCP binding sites
2
48
OD at 405 nm
0
1
2
3
4
GQNLSTSNPLGFFPDHQLDP
GFFPDHQLDPAFRANTANPD
AFRANTANPDWDFNPNKDTW
WDFNPNKDTWPDANKVG

FIGURE 6D

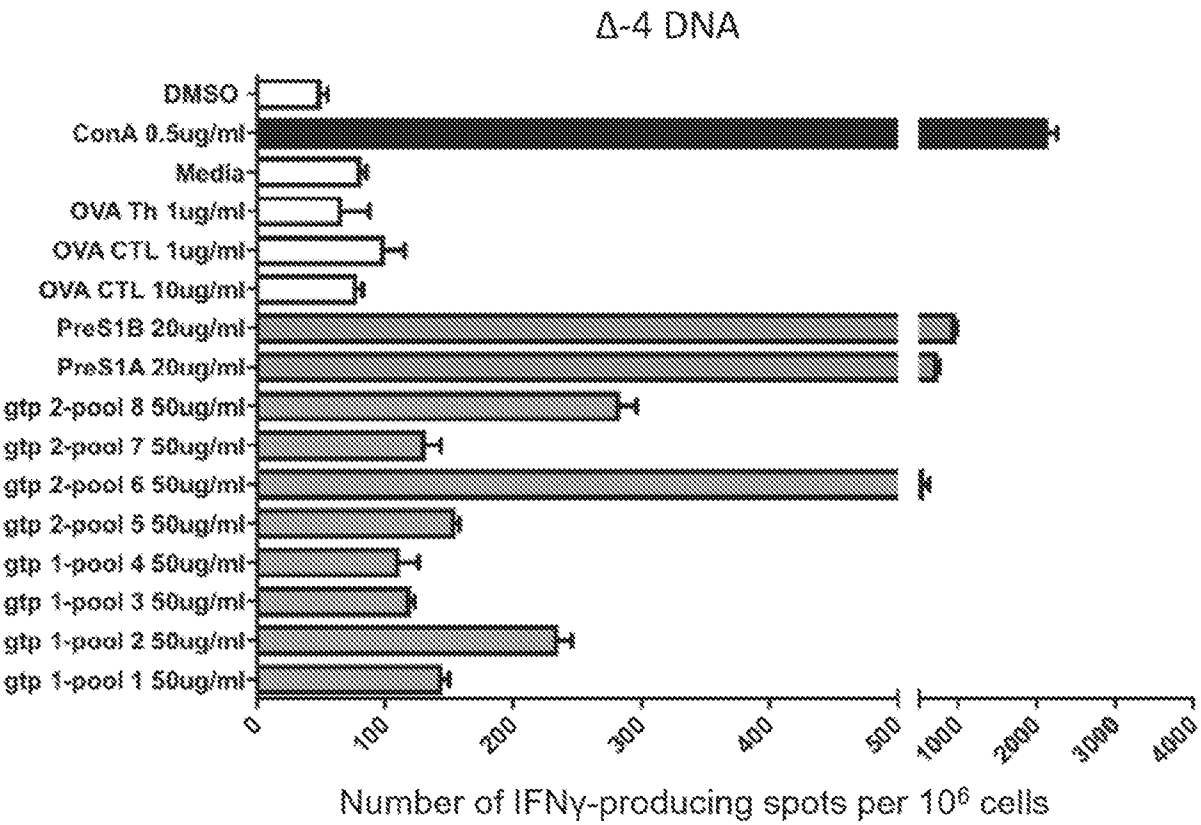

Δ-4 DNA
DMSO
ConA 8.5ug/ml
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
OVA CTL 10ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
gtp 2-pool 8 50ug/ml
gtp 2-pool 7 50ug/ml
gtp 2-pool 6 50ug/ml
gtp 2-pool 5 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
0
100
200
300
400
500
1000
2000
3000
4000
Number of IFNγ-producing spots per 10^6 cells

FIGURE 7A

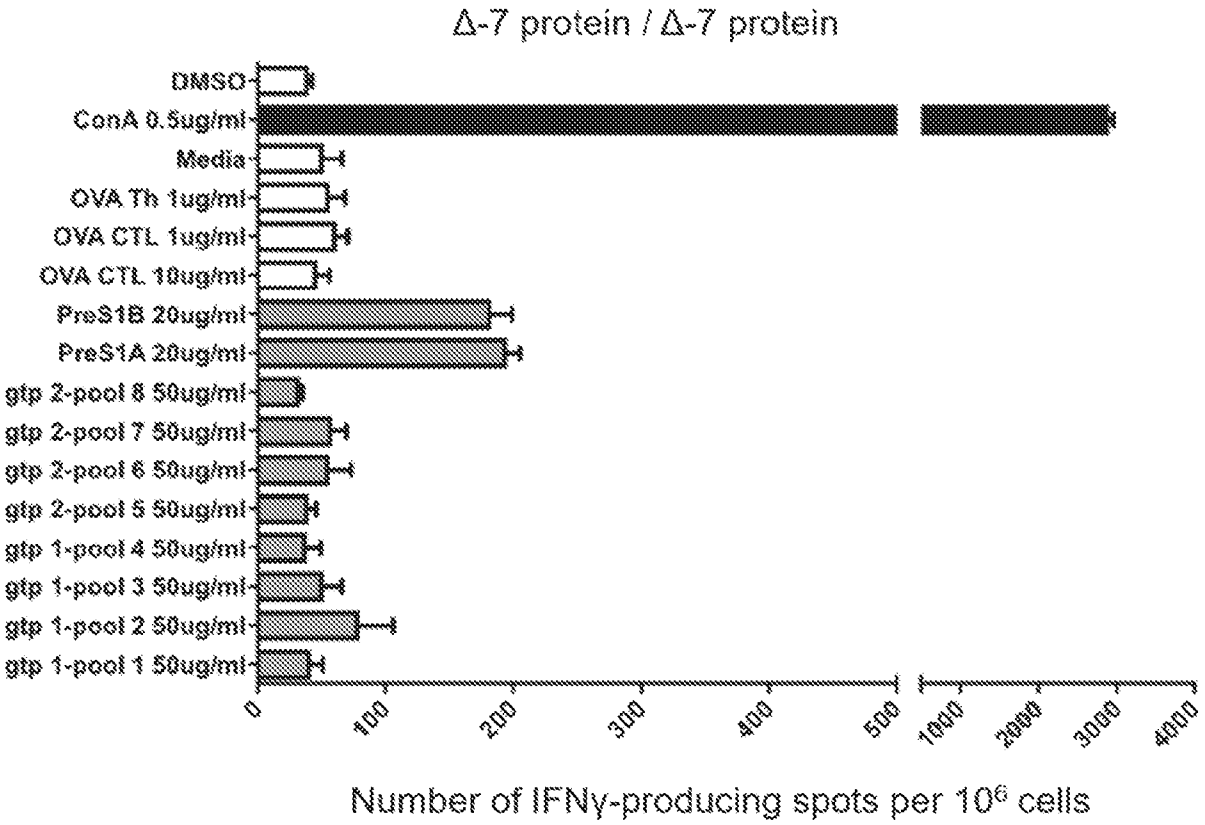

Δ-7 protein / Δ-7 protein
DMSO
ConA 0.5ug/ml
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
OVA CTL 10ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
gtp 2-pool 8 50ug/ml
gtp 2-pool 7 50ug/ml
gtp 2-pool 6 50ug/ml
gtp 2-pool 5 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
0
100
200
300
400
500
1000
2000
3000
4000
Number of IFNγ-producing spots per 10^6 cells

FIGURE 7B

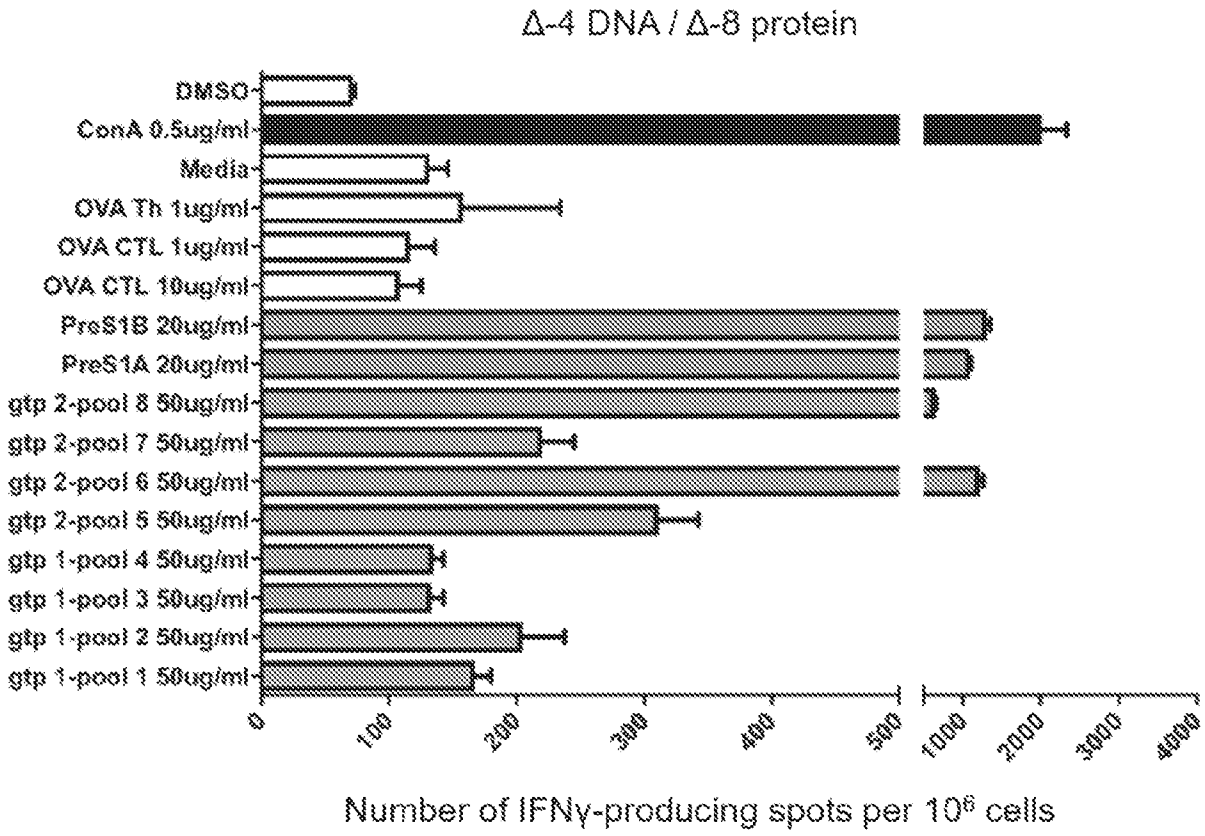

Δ-4 DNA / Δ-8 protein
DMSO
ConA 0.5ug/ml
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
OVA CTL 10ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
gtp 2-pool 8 50ug/ml
gtp 2-pool 7 50ug/ml
gtp 2-pool 6 50ug/ml
gtp 2-pool 5 50ug/ml
gtp 1-pool 4 50ug/ml
gtp 1-pool 3 50ug/ml
gtp 1-pool 2 50ug/ml
gtp 1-pool 1 50ug/ml
0
100
200
300
400
500
1000
2000
3000
4000
Number of IFNγ-producing spots per 10^6 cells

FIGURE 7C

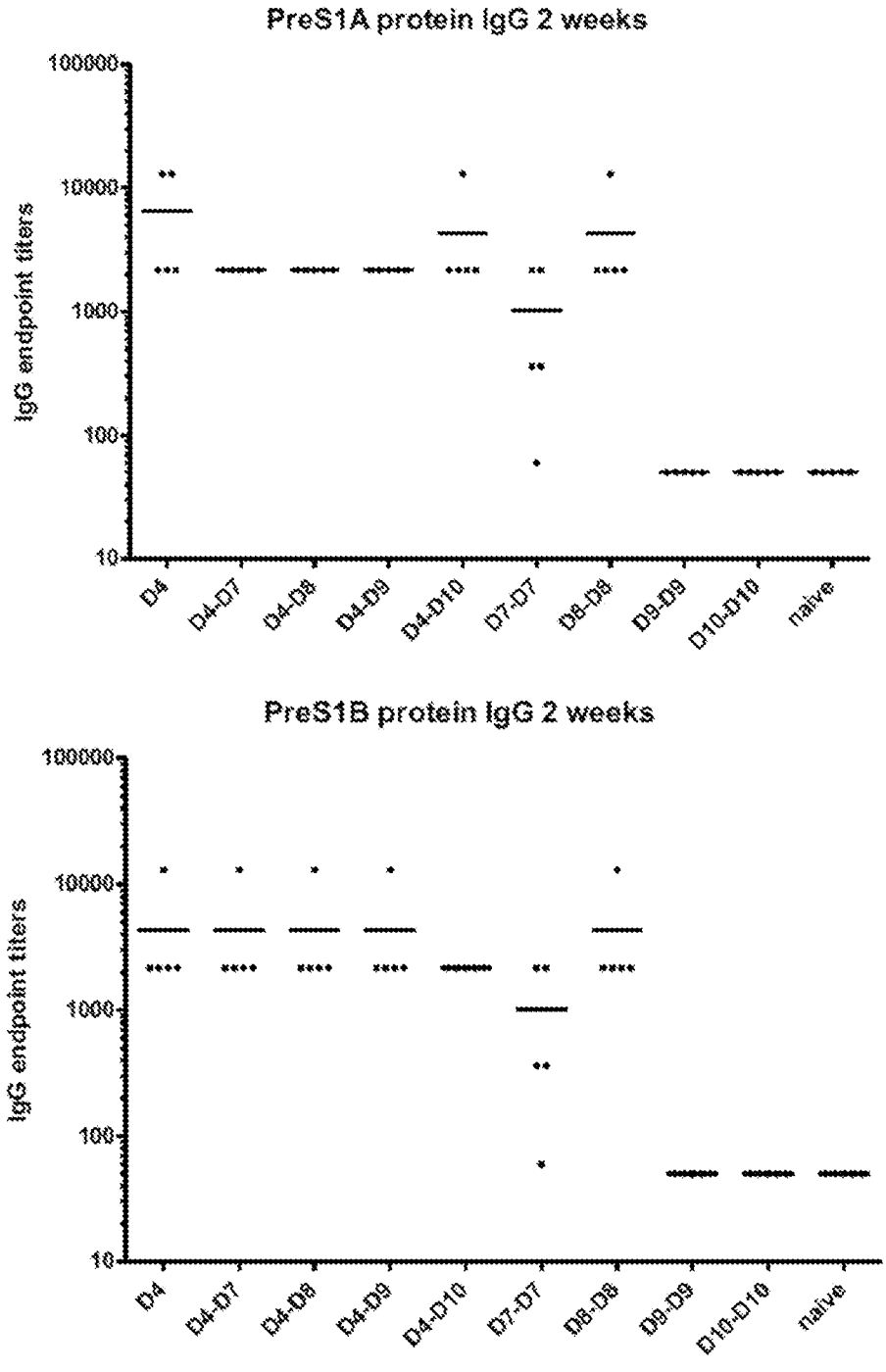

PreS1A protein IgG 2 weeks
IgG endpoint titers
100000
10000
1000
100
10
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive
PreS1B protein IgG 2 weeks
IgG endpoint titers
100000
10000
1000
100
10
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive

FIGURE 8A

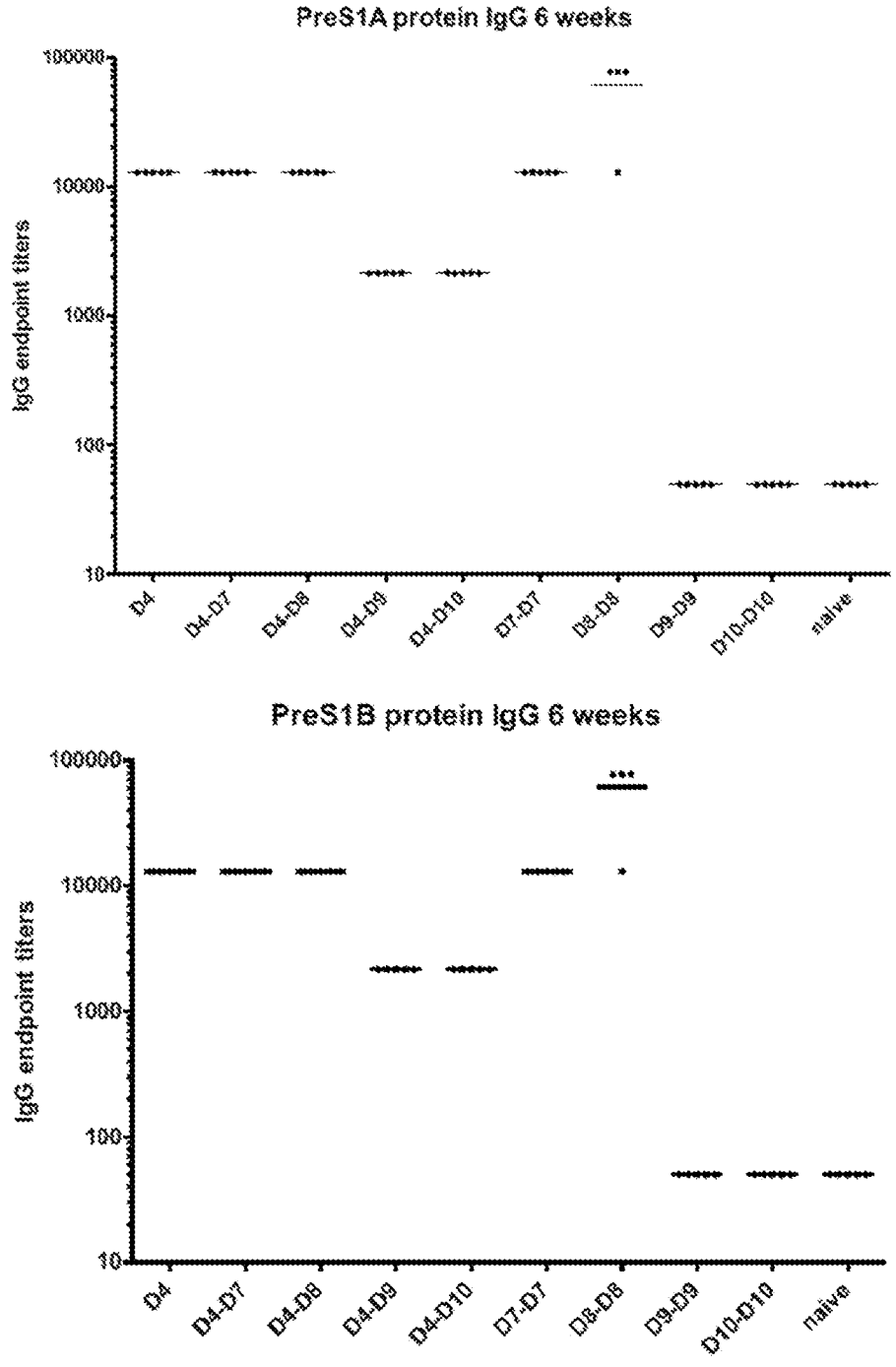

PreS1A protein IgG 6 weeks
IgG endpoint titers
100000
10000
1000
100
10
***
*
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive
PreS1B protein IgG 6 weeks
IgG endpoint titers
100000
10000
1000
100
10
***
*
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive

FIGURE 8B

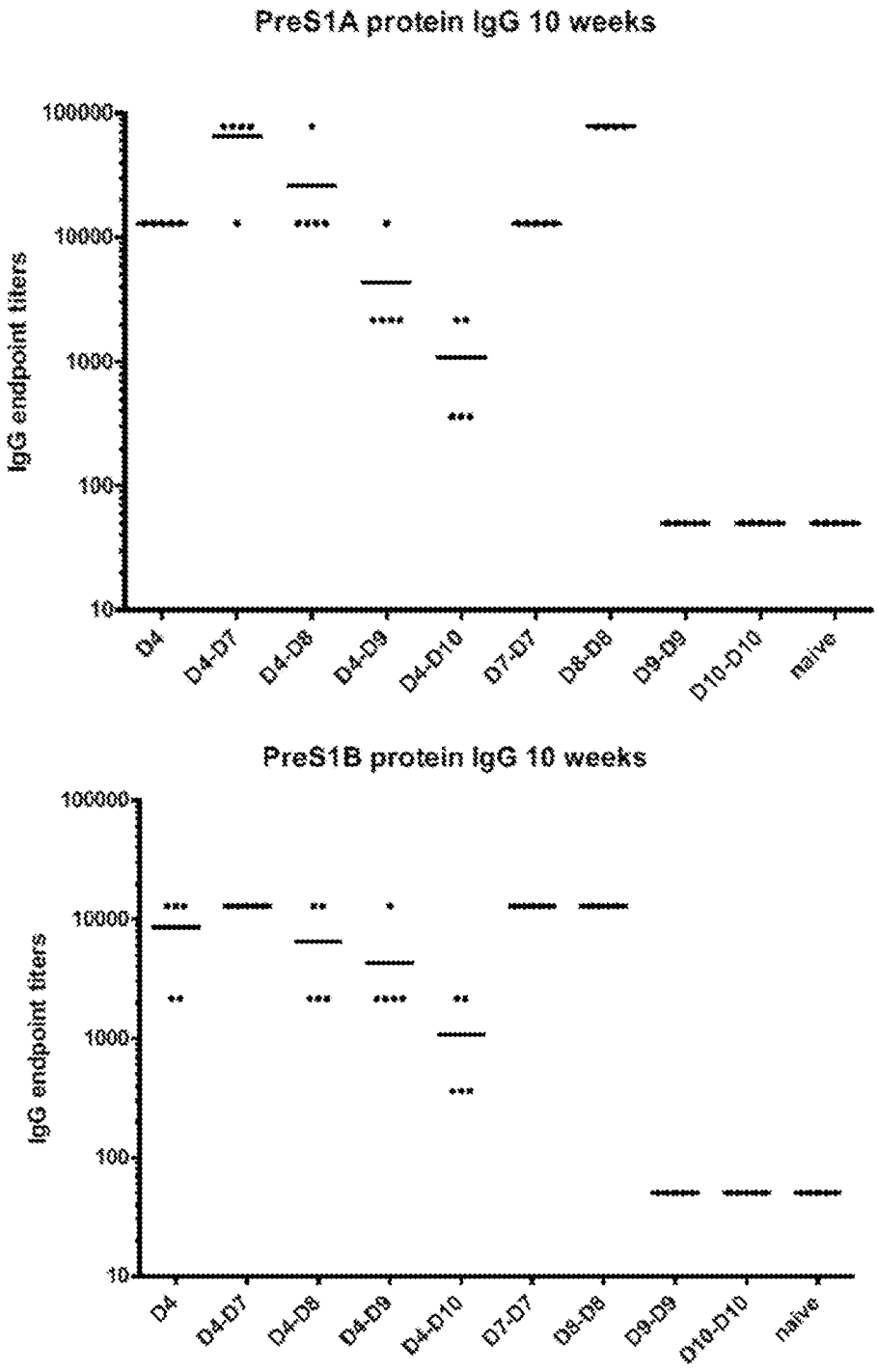

PreS1A protein IgG 10 weeks
IgG endpoint titers
100000
10000
1000
100
10
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive
PreS1B protein IgG 10 weeks
IgG endpoint titers
100000
10000
1000
100
10
D4
D4-D7
D4-D8
D4-D9
D4-D10
D7-D7
D8-D8
D9-D9
D10-D10
naive

FIGURE 8C

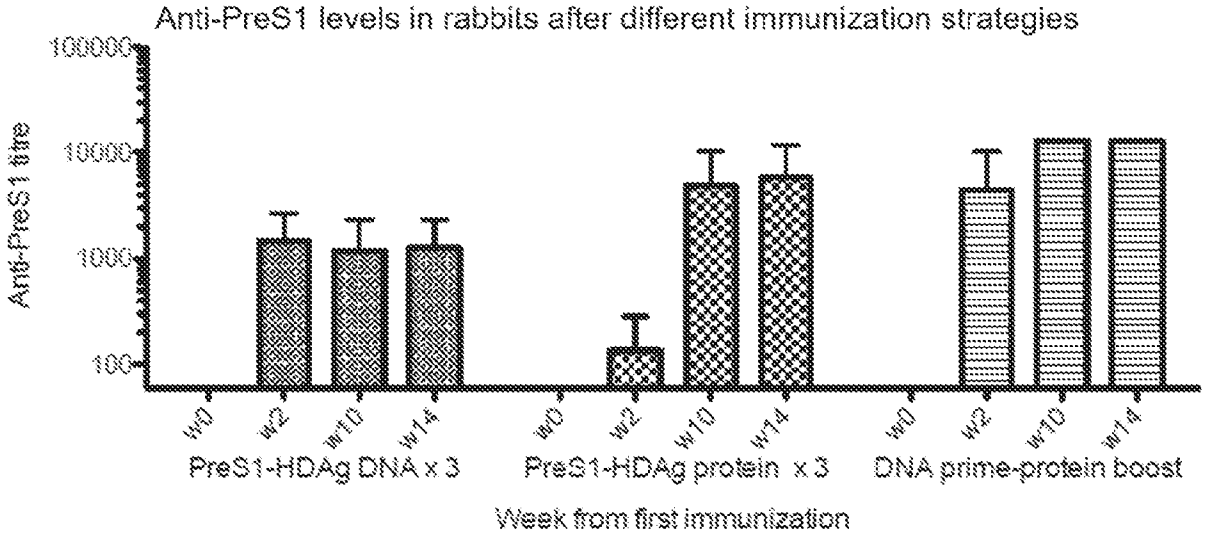

Anti-PreS1 levels in rabbits after different immunization strategies
Anti-PreS1 titre
100000
10000
1000
100
w0
w2
w10
w14
PreS1-HDAg DNA x 3
PreS1-HDAg protein x 3
DNA prime-protein boost
Week from first immunization

FIGURE 9

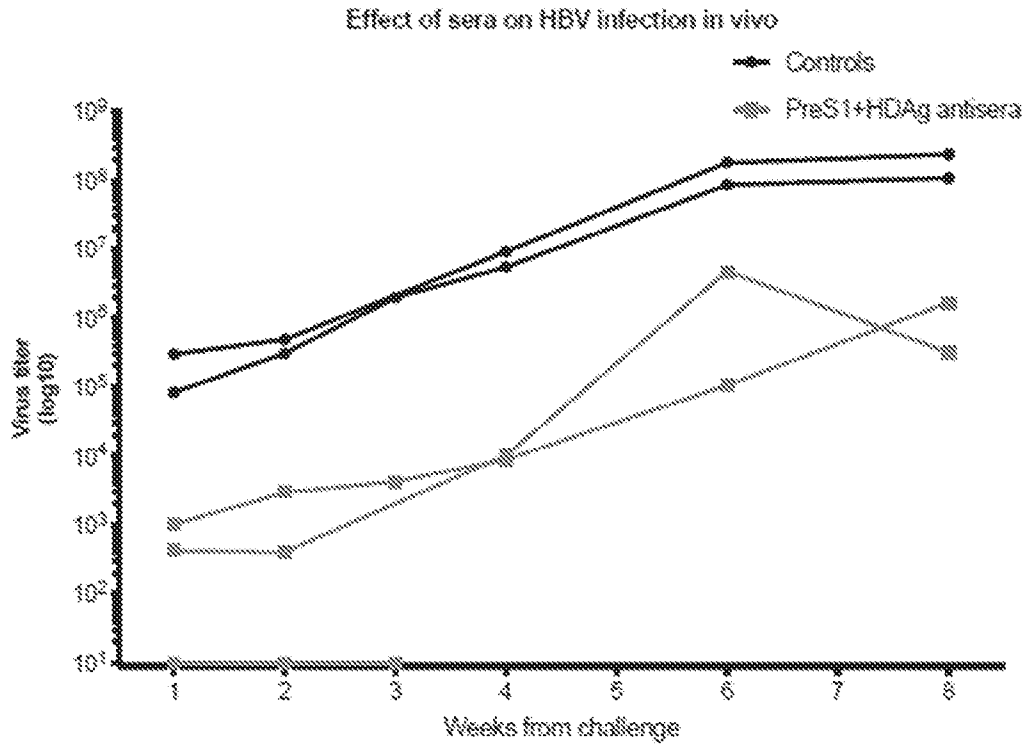

Effect of sera on HBV infection in vivo
Controls
PreS1+HDAg antisera
Virus titer (log10)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
1
2
3
4
5
6
7
8
Weeks from challenge

FIGURE 10A

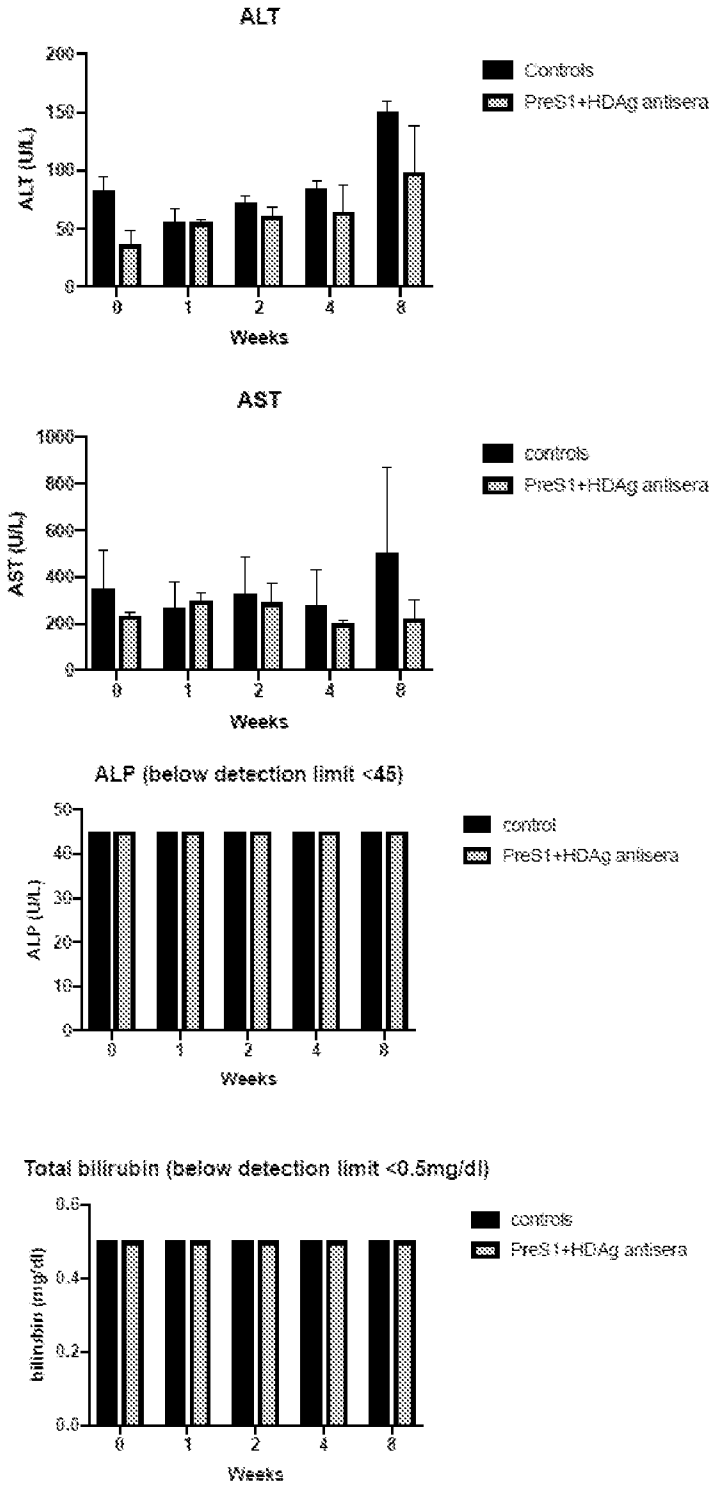

ALT
ALT (U/L)
200
150
100
50
0
0
1
2
4
8
Weeks
Controls
PreS1+HDAg antisera
AST
AST (U/L)
1000
800
600
400
200
0
Weeks
controls
PreS1+HDAg antisera
ALP (below detection limit <45)
ALP (U/L)
50
40
30
20
10
0
Weeks
control
PreS1+HDAg antisera
Total bilirubin (below detection limit <0.5mg/dl)
bilirubin (mg/dl)
0.6
0.4
0.2
0.0
Weeks
controls
PreS1+HDAg antisera

FIGURE 10B

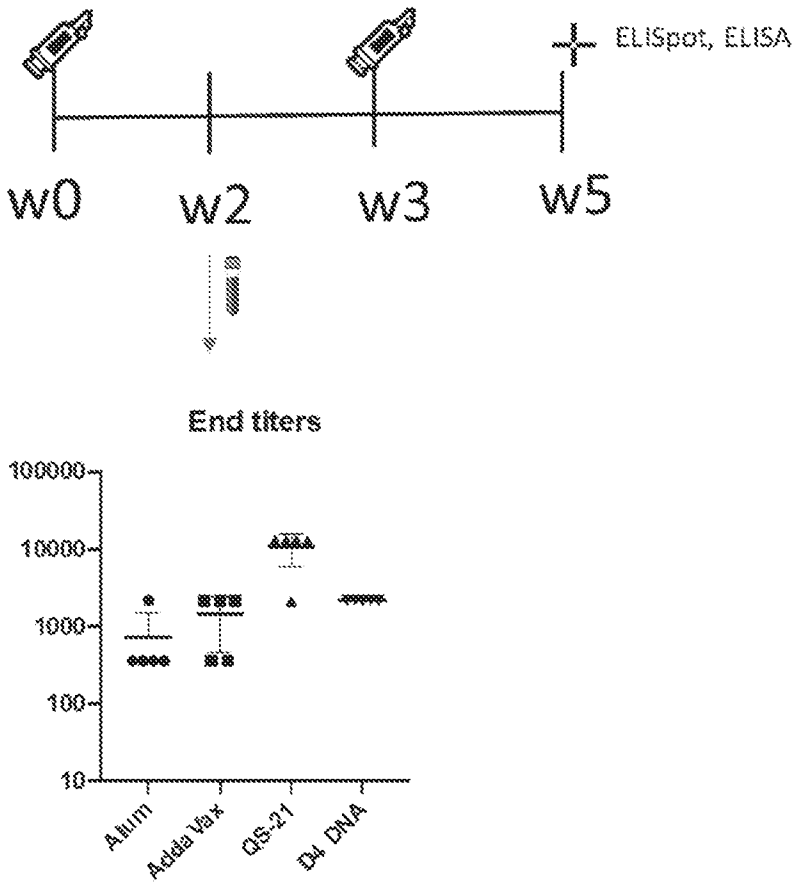

ELISpot, ELISA
w0
w2
w3
w5
End titers
100000
10000
1000
100
10
Alum
Addavax
QS-21
D4 DNA

FIGURE 11A

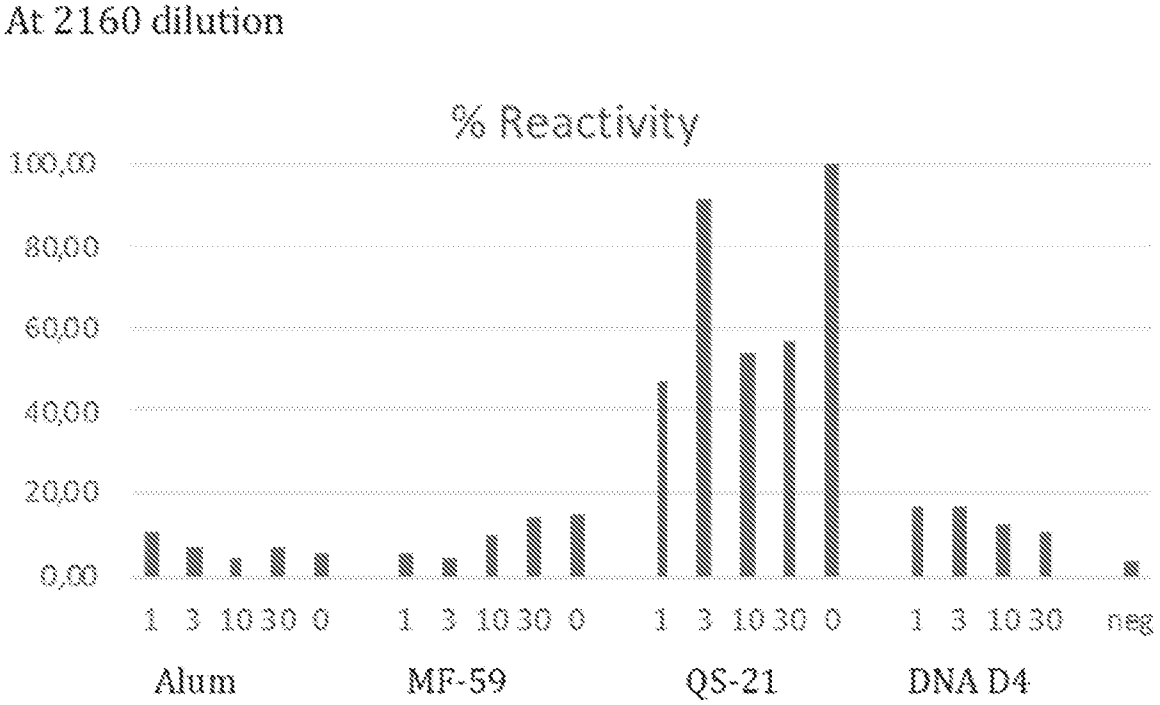

At 2160 dilution
% Reactivity
100,00
80,00
60,00
40,00
20,00
0,00
1 3 10 30 0 1 3 10 30 0 1 3 10 30 0 1 3 10 30 neg
Alum
MF-59
QS-21
DNA D4

FIGURE 11B

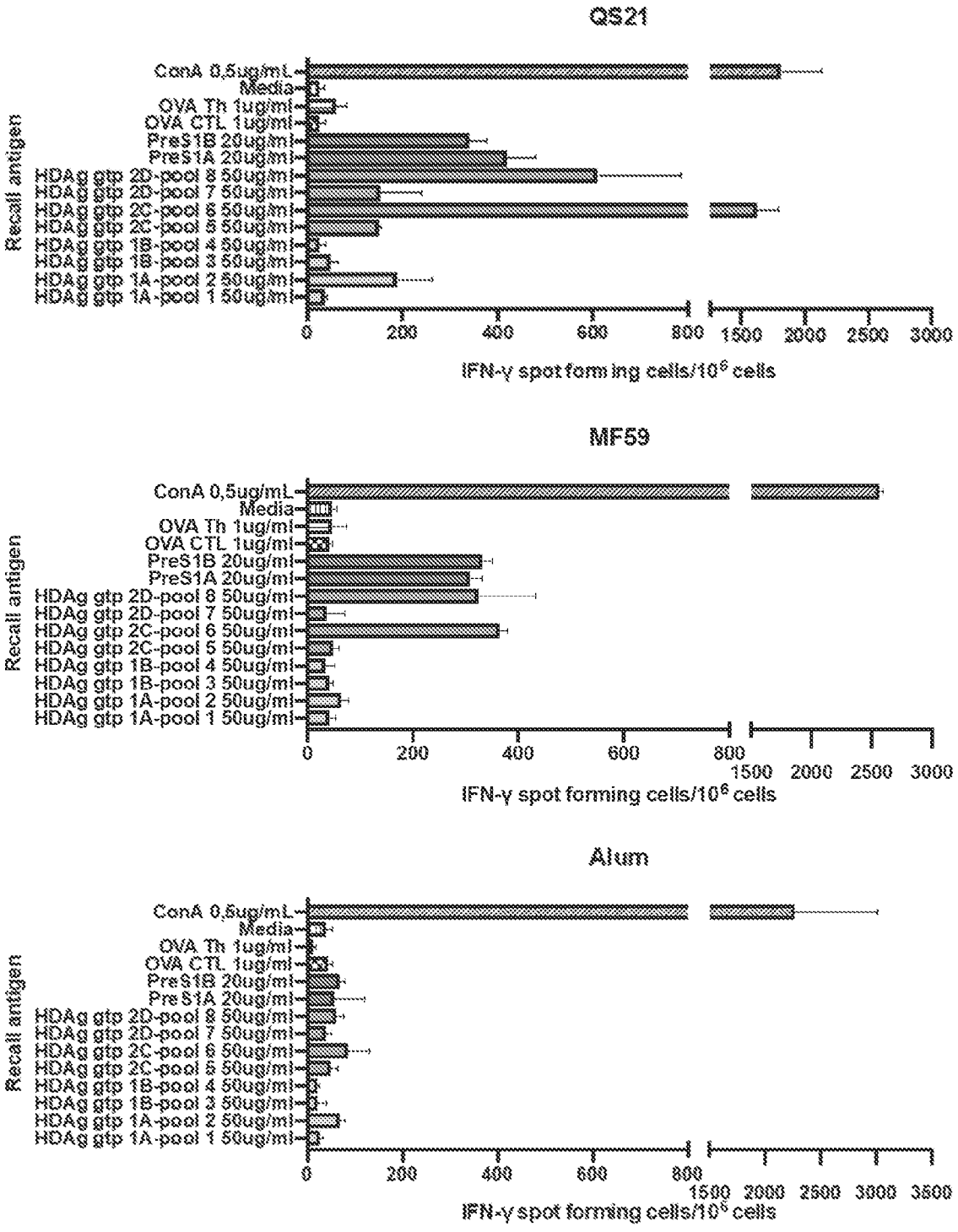

QS21
ConA 0,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
200
400
600
800
1500
2000
2500
3000
IFN-γ spot forming cells/10^6 cells
MF59
ConA 0,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
200
400
600
800
1500
2000
2500
3000
IFN-γ spot forming cells/10^6 cells
Alum
ConA 0,5ug/mL
Media
OVA Th 1ug/ml
OVA CTL 1ug/ml
PreS1B 20ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
200
400
600
800
1500
2000
2500
3000
3500
IFN-γ spot forming cells/10^6 cells

FIGURE 11C

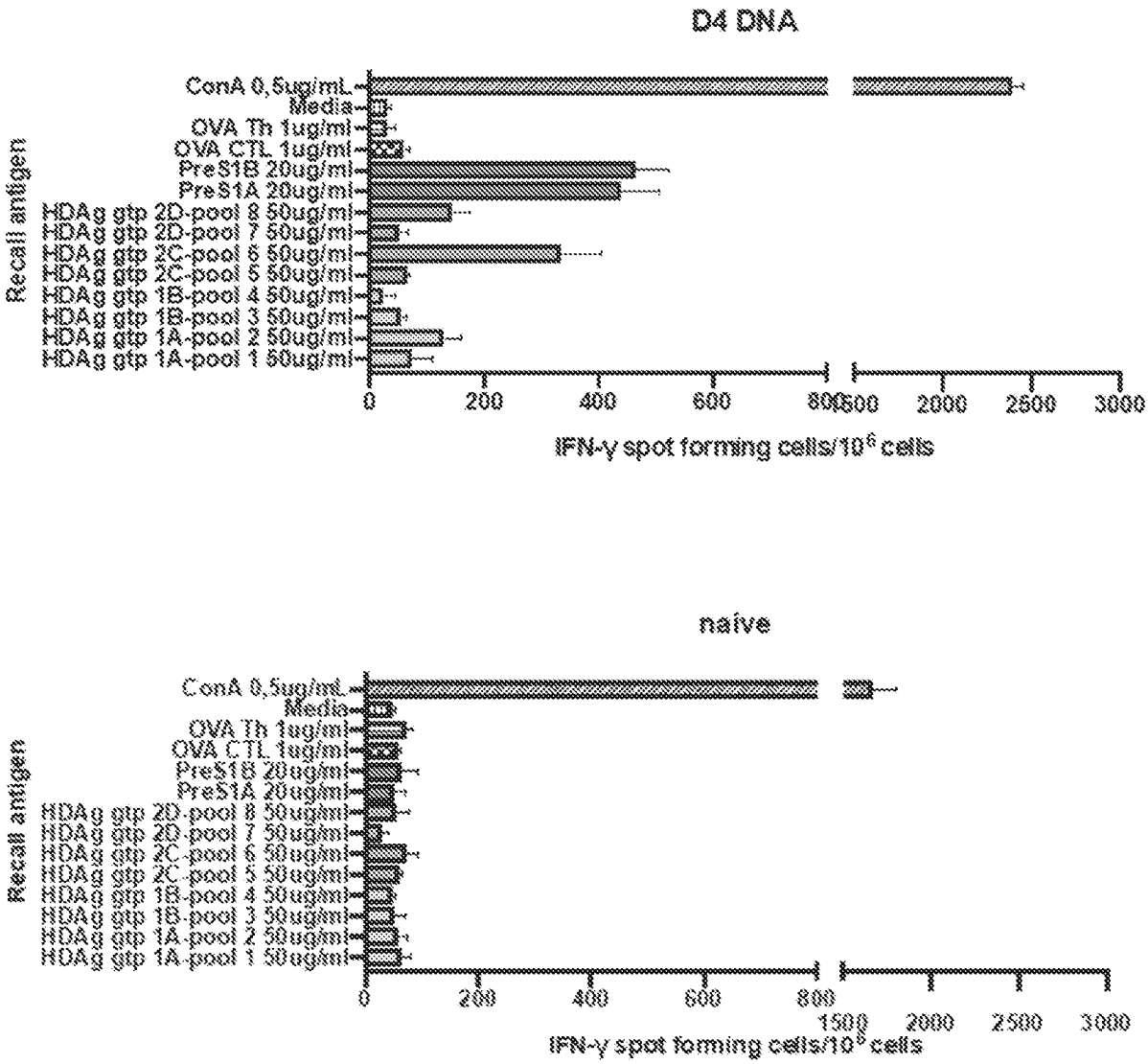


FIGURE 11C cont.

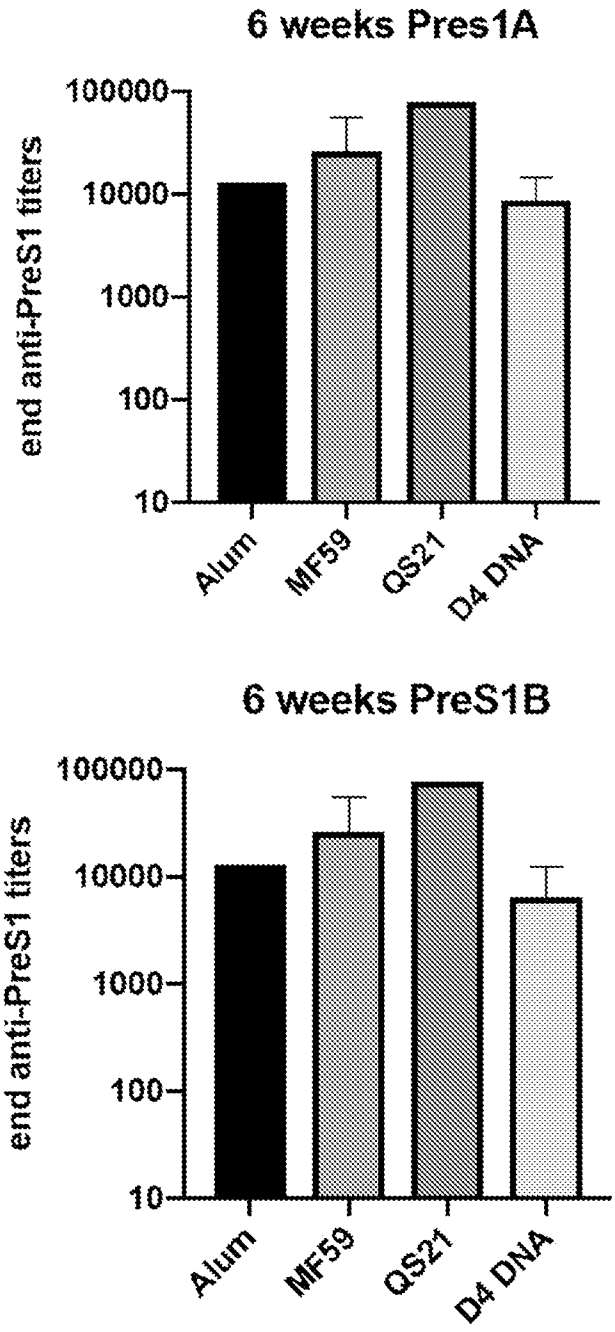

6 weeks Pres1A
end anti-PreS1 titers
100000
10000
1000
100
10
Alum
MF59
QS21
D4 DNA
6 weeks PreS1B
end anti-PreS1 titers
100000
10000
1000
100
10
Alum
MF59
QS21
D4 DNA

FIGURE 11D

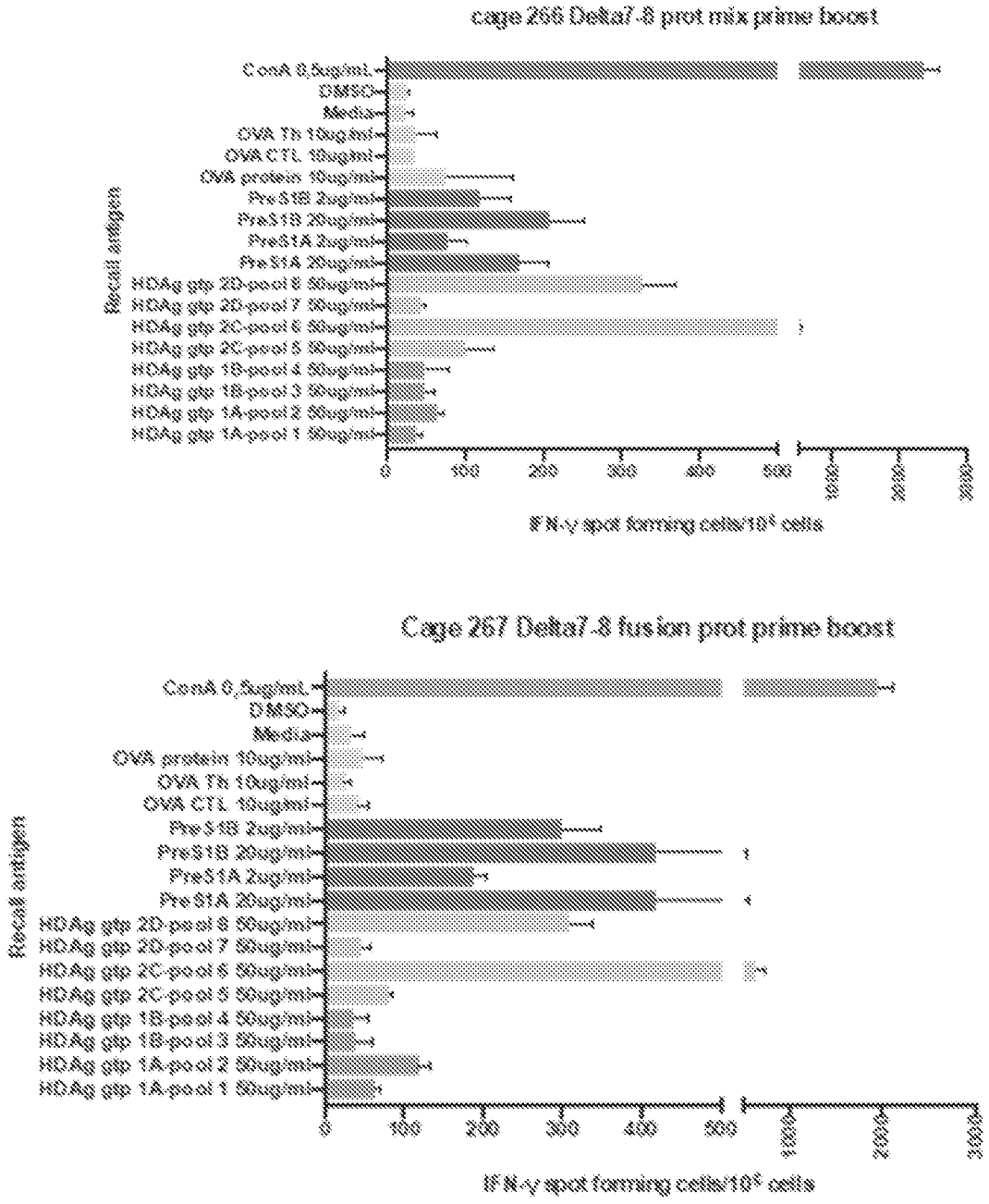

cage 266 Delta7-8 prot mix prime boost
ConA 0.5ug/mL
DMSO
Media
OVA Th 10ug/ml
OVA CTL 10ug/ml
OVA protein 10ug/ml
PreS1B 2ug/ml
PreS1B 20ug/ml
PreS1A 2ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
2000
3000
IFN-γ spot forming cells/10^6 cells
Cage 267 Delta7-8 fusion prot prime boost
ConA 0.5ug/mL
DMSO
Media
OVA protein 10ug/ml
OVA Th 10ug/ml
OVA CTL 10ug/ml
PreS1B 2ug/ml
PreS1B 20ug/ml
PreS1A 2ug/ml
PreS1A 20ug/ml
HDAg gtp 2D-pool 8 50ug/ml
HDAg gtp 2D-pool 7 50ug/ml
HDAg gtp 2C-pool 6 50ug/ml
HDAg gtp 2C-pool 5 50ug/ml
HDAg gtp 1B-pool 4 50ug/ml
HDAg gtp 1B-pool 3 50ug/ml
HDAg gtp 1A-pool 2 50ug/ml
HDAg gtp 1A-pool 1 50ug/ml
Recall antigen
0
100
200
300
400
500
1000
2000
3000
IFN-γ spot forming cells/10^6 cells

FIGURE 12A

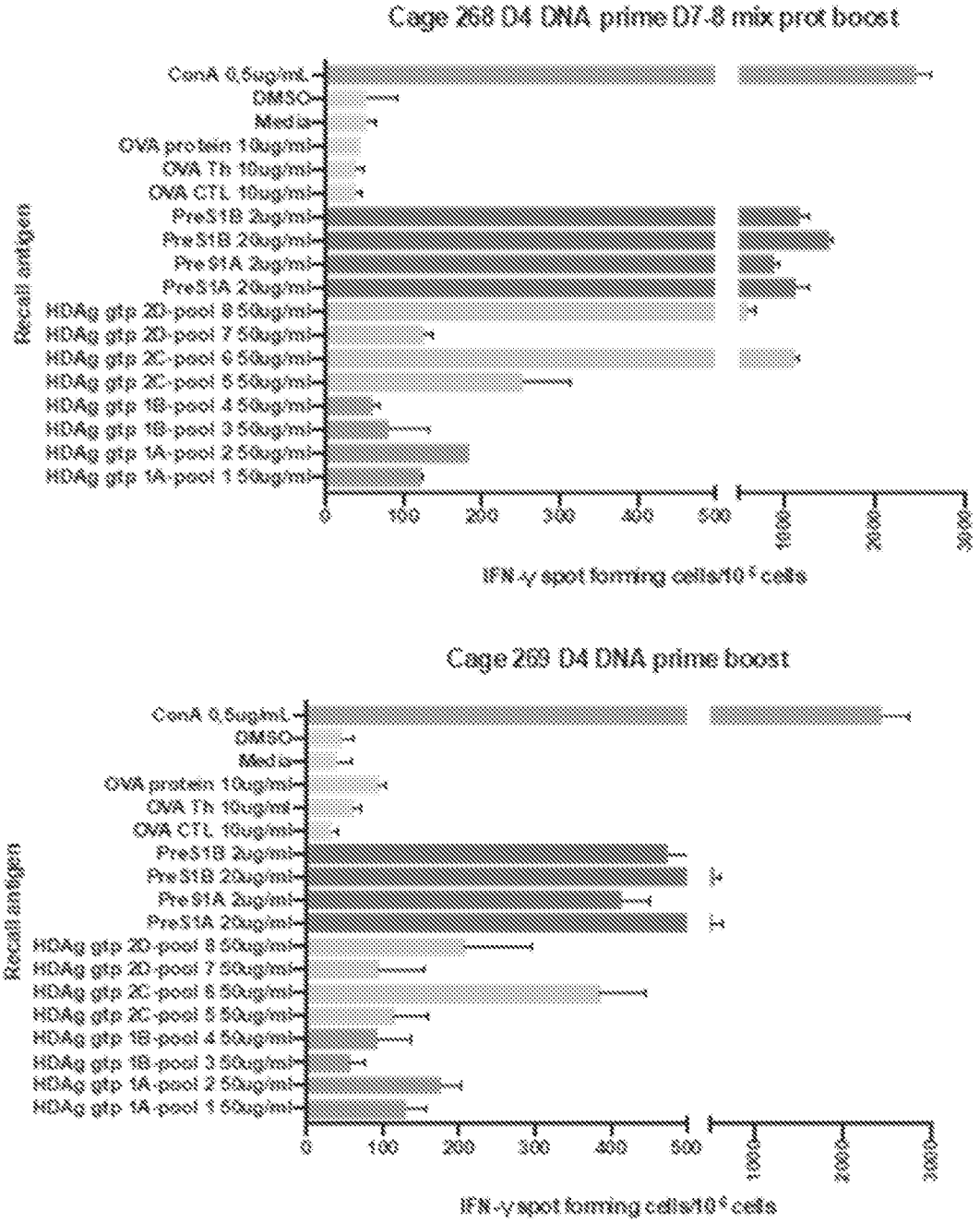


FIGURE 12A cont.

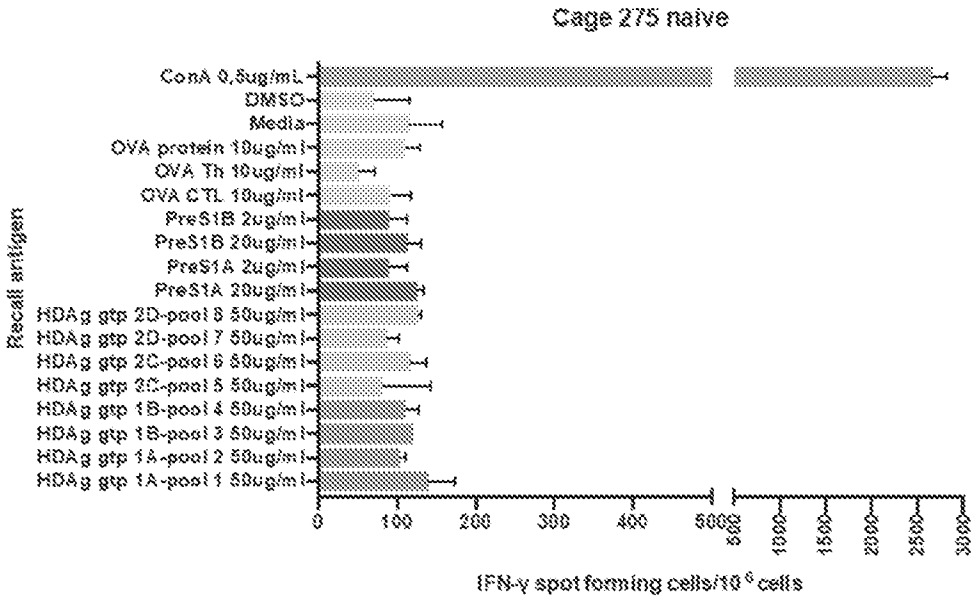


FIGURE 12A cont.

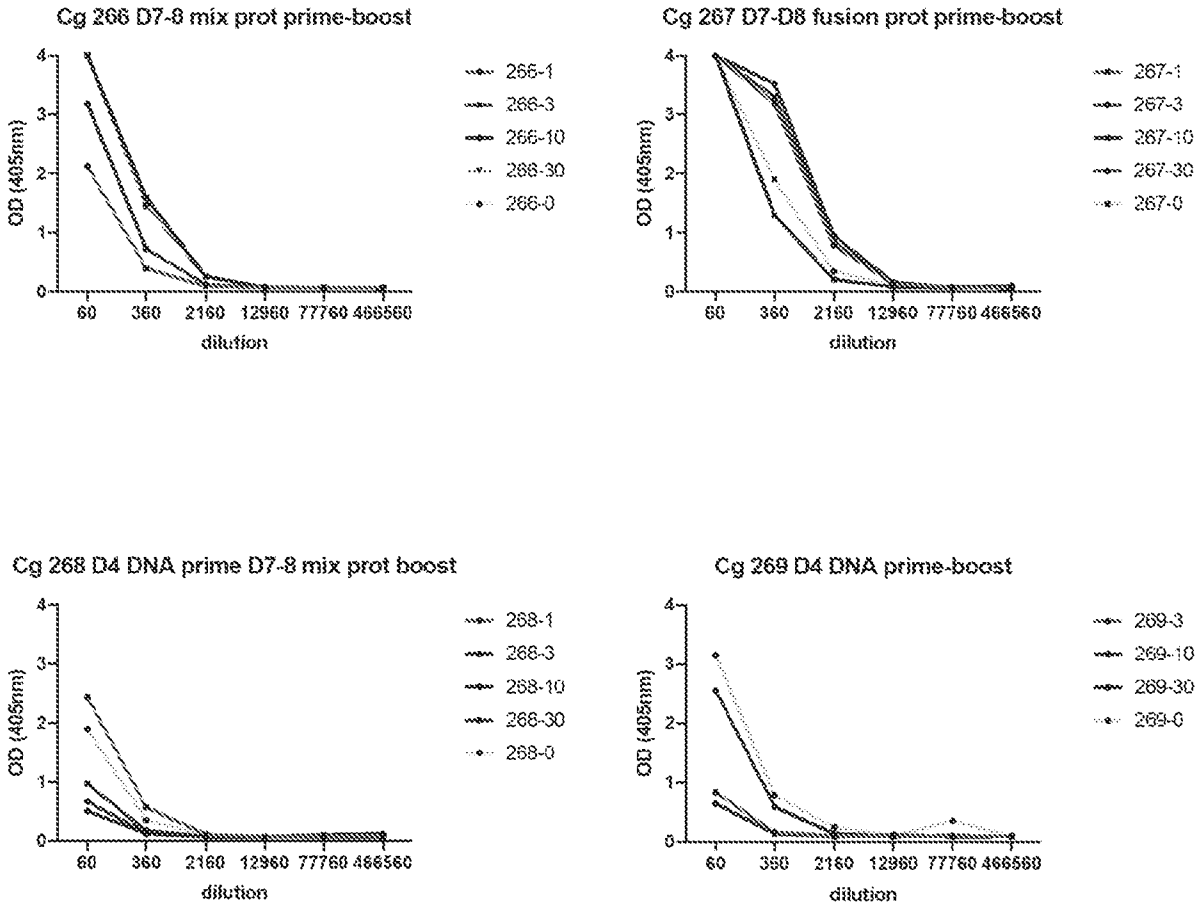

Cg 266 D7-8 mix prot prime-boost
OD (405nm)
dilution
60
360
2160
12960
77760
466560
266-1
266-3
266-10
266-30
266-0
Cg 267 D7-D8 fusion prot prime-boost
267-1
267-3
267-10
267-30
267-0
Cg 268 D4 DNA prime D7-8 mix prot boost
268-1
268-3
268-10
268-30
268-0
Cg 269 D4 DNA prime-boost
269-3
269-10
269-30
269-0

FIGURE 12B

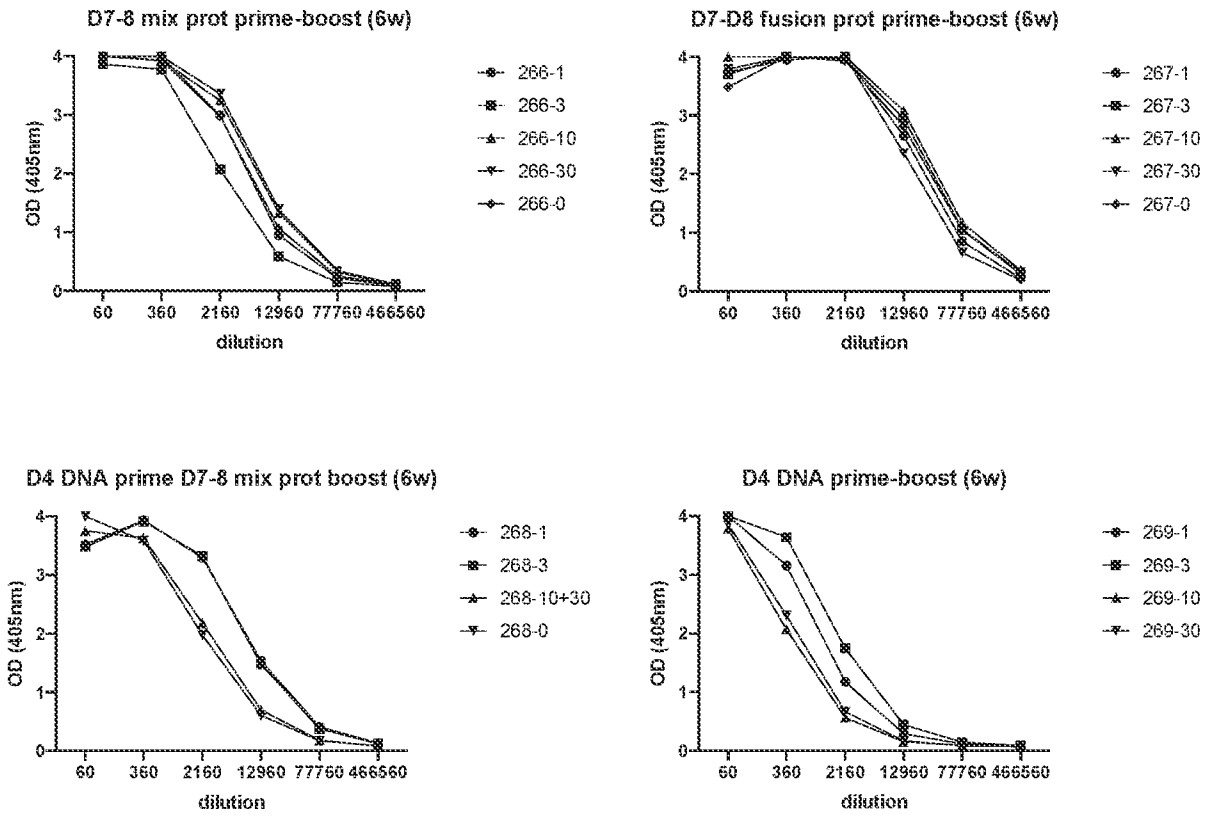

D7-8 mix prot prime-boost (6w)
OD (405nm)
dilution
60 360 2160 12960 77760 466560
266-1
266-3
266-10
266-30
266-0
D7-D8 fusion prot prime-boost (6w)
267-1
267-3
267-10
267-30
267-0
D4 DNA prime D7-8 mix prot boost (6w)
268-1
268-3
268-10+30
268-0
D4 DNA prime-boost (6w)
269-1
269-3
269-10
269-30

FIGURE 12C

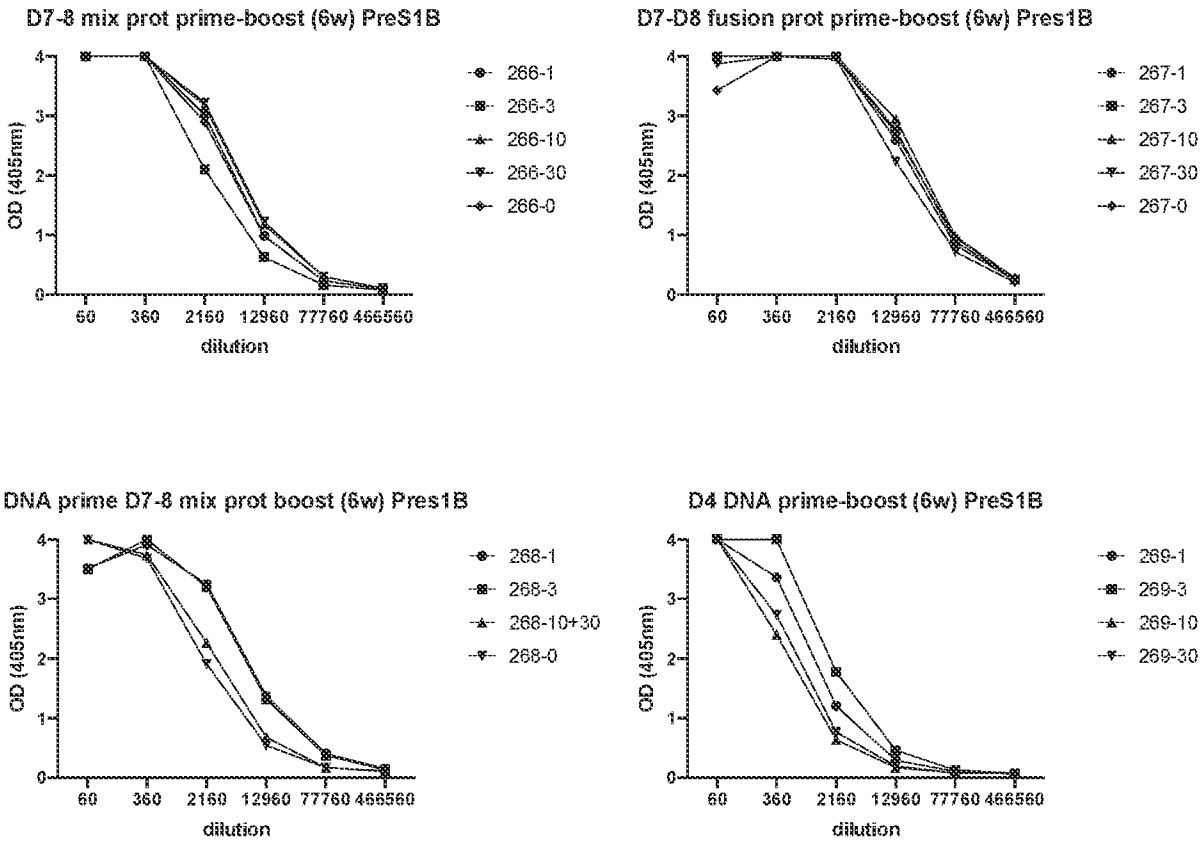

D7-8 mix prot prime-boost (6w) PreS1B
OD (405nm)
dilution
60
360
2160
12960
77760
466560
266-1
266-3
266-10
266-30
266-0
D7-D8 fusion prot prime-boost (6w) Pres1B
267-1
267-3
267-10
267-30
267-0
DNA prime D7-8 mix prot boost (6w) Pres1B
268-1
268-3
268-10+30
268-0
D4 DNA prime-boost (6w) PreS1B
269-1
269-3
269-10
269-30

FIGURE 12D

SEQUENCE LISTING

<110> Svenska Vaccinfabriken Produktion AB

<120> COMPOSITIONS AND METHODS FOR TREATING AND PREVENTING HEPATITIS B AND D

<130> SVF.005WO

<150> US 62/966970
<151> 2020-01-28

<160> 39

<170> PatentIn version 3.5

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<223> HDAg genotype 1 A DNA sequence

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aaaaaactgg aagaagaaaa cccgtggctg ggcaacatta aaggcattct gggcaaaaaa 180

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aaaaaactgg aagatgataa cccgtggctg ggcaacgtga aaggcattct gggcaaaaaa 180

gataaagatg gcgaaggcgc gccgccggcg aaacgcgcgc gcaccgatca gatggaaatt 240

gatagcggcc cgcgcaaacg cccgctgcgc ggcggcttta ccgatcgcga acgccaggat 300

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attaaaaaac tggaagatga aaacccgtgg ctgggcaaca ttattggcat tattcgcaaa 180

ggcaaagatg gcgaaggcgc gccgccggcg aaacgcccgc gcaccgatca gatggaaatt 240

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20 25 30

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Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg Glu Gly
    50                  55                  60

Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met Glu Val
65                  70                  75                  80

Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr Asp Lys
                85                  90                  95

Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Arg Lys
            100                 105                 110

Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu
        115                 120                 125

Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg Val Ala
    130                 135                 140

Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr Arg Gly
145                 150                 155                 160

Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro Glu Ser
                165                 170                 175

Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn Gln Gly
            180                 185                 190

Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser Pro Gln
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Ser Cys Arg Pro Gln
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<213> Artificial Sequence

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<223> HDAg genotype 1 B polypeptide sequence

<400> 6

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            20                  25                  30


Leu Arg Arg Ala Arg Lys Lys Ile Lys Lys Leu Glu Asp Asp Asn Pro
        35                  40                  45


Trp Leu Gly Asn Val Lys Gly Ile Leu Gly Lys Lys Asp Lys Asp Gly
    50                  55                  60


Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Thr Asp Gln Met Glu Ile
65                  70                  75                  80


Asp Ser Gly Pro Arg Lys Arg Pro Leu Arg Gly Gly Phe Thr Asp Arg
                85                  90                  95


Glu Arg Gln Asp His Arg Arg Arg Lys Ala Leu Lys Asn Lys Lys Lys
            100                 105                 110


Gln Leu Ser Ala Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu
        115                 120                 125


Leu Lys Arg Leu Thr Arg Glu Asp Glu Glu Arg Lys Lys Glu Glu His
    130                 135                 140


Gly Pro Ser Arg Leu Gly Val Asn Pro Ser Glu Gly Gly Pro Arg Gly
145                 150                 155                 160


Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Ile Pro Glu Ser
                165                 170                 175


Arg Phe Thr Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Ser Arg Gly
            180                 185                 190


Phe Pro Gln Asp Ile Leu Phe Pro Ser Asp Pro Pro Phe Ser Pro Gln
        195                 200                 205
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Ser Cys Arg Pro Gln
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<210> 7
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<400> 7

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20 25 30

Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu Glu Asn
35 40 45

Pro Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys Asp Gly
50 55 60

Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu Val
65 70 75 80

Asp Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp Lys
85 90 95

Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys
100 105 110

Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu Glu Glu
115 120 125

Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg Val Ala
130 135 140

Gly Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro Arg Gly
145 150 155 160

Ala Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro Glu Ser
165 170 175

Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr Gln Gly
180 185 190

Phe Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro Leu Leu
195 200 205

Glu Cys Thr Pro Gln
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<212> PRT
<213> Artificial Sequence

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<223> HDAg genotype 2 B polypeptide sequence

<400> 8

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1 5 10 15

Leu Glu Lys Trp Ile Thr Thr Arg Arg Lys Ala Glu Glu Leu Glu Lys
20 25 30

Asp Leu Arg Lys Ala Arg Lys Thr Ile Lys Lys Leu Glu Asp Glu Asn
35 40 45

Pro Trp Leu Gly Asn Ile Ile Gly Ile Ile Arg Lys Gly Lys Asp Gly
50 55 60

Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu Ile
65 70 75 80

Asp Ser Gly Thr Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp Lys
85 90 95

Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys
100 105 110

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Gln Leu Ser Ser Gly Gly Lys Asn Leu Ser Arg Glu Glu Glu Glu Glu
        115                 120                 125


Leu Gly Arg Leu Thr Val Glu Asp Glu Glu Arg Arg Arg Arg Val Ala
    130                 135                 140


Gly Pro Arg Thr Gly Asp Val Asn Leu Ser Gly Gly Gly Pro Arg Gly
145                 150                 155                 160


Ala Pro Gly Gly Gly Phe Val Pro Arg Met Glu Gly Val Pro Glu Ser
                165                 170                 175


Pro Phe Thr Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Asn Gln Gly
            180                 185                 190


Phe Pro Trp Val Arg Pro Ser Pro Pro Gln Gln Arg Leu Pro Leu Leu
        195                 200                 205


Glu Cys Thr Pro Gln
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<223> PreS1 A DNA sequence

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gcgtttcgcg cgaacagcgc gaacccggat tgggatttta acccgaacaa agatacctgg 120

ccggatgcga acaaagtggg c 141

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<212> DNA
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<223> PreS1 B DNA sequence

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gcgtttcgcg cgaacaccgc gaacccggat tgggatttta acccgaacaa agatacctgg 120

ccggatgcga acaaagtggg c 141

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<223> PreS1 A polypeptide sequence

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Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp
20 25 30

Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
35 40 45

<210> 12
<211> 47
<212> PRT
<213> Artificial Sequence

<220>
<223> PreS1 B polypeptide sequence

<400> 12

Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His
1 5 10 15

Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp
20 25 30

Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
35 40 45

<210> 13
<211> 66

<212> DNA
<213> Artificial Sequence

<220>
<223> P2A autocatalytic peptide cleavage site DNA sequence

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ggacct 66

<210> 14
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<212> PRT
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<220>
<223> P2A autocatalytic peptide cleavage site polypeptide sequence

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Glu Glu Asn Pro Gly Pro
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aagatcaaga agctggagga ggagaacccc tggctgggca atatcaaggg catcctgggc 180

aagaaggatc gggagggaga gggagcacca cctgcaaaga gggccagagc cgaccagatg 240

gaggtggata gcggaccaag gaagcgccct ttcagaggag agtttaccga caaggagcgg 300

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aagaagaaca ggggaggaag agaggaggtg ctggagcagt gggtgaatgg ccggaagaag 720

ctggaggagc tggagcggga gctgagaagg gccagaaaga agatcaagaa gctggaagac 780

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ttctttcctg accaccagct ggatcctgcc ttcagggcca acaccgccaa tcccgactgg 240

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<211> 3762
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<223> Delta-3 codon optimized DNA sequence

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gatcatcagc tggatccagc ctttagagcc aataccgcca accctgactg ggatttcaac 3720

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<210> 18
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<223> Delta-4 codon optimized DNA sequence

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<220>
<223> Delta-6 codon optimized DNA sequence

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<213> Artificial Sequence

<220>
<223> Delta-7 codon optimized DNA sequence

<400> 21
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agggagcgcc gggtggccgg cccaagggtg ggcggcgtga acccccctgga gggaggaacc 480

aggggagcac caggaggagg cttcgtgcct tctatgcagg gcgtgccaga gagccccttt 540

gccaggacag gagagggcct ggatgtgcgc ggcaatcagg gcttcccatg ggacatcctg 600

tttcccgccg atccaccctt ctcccctcag tcttgcaggc cacagtcccg ctctgagagc 660

aagaagaaca ggggaggaag ggaggaggtg ctggagcagt gggtgaatgg caggaagaag 720

ctggaggagc tggagcggga gctgagaagg gccagaaaga agatcaagaa gctggaagac 780

gataatcctt ggctgggcaa tgtgaaaggc atcctgggca agaaggacaa ggatggagag 840

ggagcacctc cagcaaagag ggcacgcacc gaccagatgg agatcgattc cggaccaagg 900

aagcggcccc tgaggggagg cttcacagac agggagcgcc aggatcaccg ccggagaaag 960

gccctgaaga acaagaagaa gcagctgtct gccggcggca agtccctgtc taaagaagag 1020

gaggaggagc tgaagcggct gaccagagag gacgaggagc ggaagaagga ggagcacggc 1080

ccttccagac tgggcgtgaa tccatctgag ggaggaccaa gaggcgcccc tggcggaggc 1140

ttcgtgccta gcatgcaggg catcccagag tccaggttta ccagaaccgg agagggcctg 1200

gacgtgcggg gctctagagg ctttccccag gacatcctgt tccctagcga tccccctttt 1260

agcccccagt cctgtaggcc tcagggcacc aacctgagca catccaatcc actgggcttc 1320

tttccagacc accagctgga tccagccttc cgcgccaaca gcgccaatcc agactgggac 1380

ttcaacccca ataaggacac ctggcctgat gccaacaagg tcggcggcca gaacctgtct 1440

acaagcaatc ctctgggctt ctttcctgat caccagctgg atcctgcctt tcgggccaat 1500

acagccaacc ctgactggga cttcaatcct aacaaagaca cttggcccga tgctaataag 1560

gtcggctga 1569

<210> 22
<211> 1569

<212> DNA
<213> Artificial Sequence

<220>
<223> Delta-8 codon optimized DNA sequence

<400> 22
atggccagtc agagcgagac ccgcagagga cggagaggaa cacgagaaga gacactggag 60

aaatggatta cagcacggaa gaaggcagaa gagctggaga aggacctgag gaagacccgc 120

aagacaatca agaagctgga ggaggagaac ccctggctgg gcaatatcgt gggcatcatc 180

aggaagggca aggatggaga gggagcacca cctgccaaga ggcctcgcac agaccagatg 240

gaggtggata gcggaccagg caagcggcct cacaagtccg gcttcaccga caaggagaga 300

gaggatcacc ggagaaggaa ggccctggag aacaagaaga agcagctgtc cgccggcggc 360

aagatcctgt ctaaggagga ggaggaggag ctgcgccggc tgacagacga ggatgaggag 420

aggaagagaa gggtggcagg accaagggtg ggcgacgtga atccttctag gggaggacca 480

aggggagcac caggaggagg cttcgtgcct cagatggccg gcgtgccaga gtctcccttt 540

agccggacag gcgagggcct ggatatcaga ggcacccagg gctttccttg ggtgtctcca 600

agcccaccac agcagcggct gccactgctg gagtgcacac cccagtccca gtctgagagc 660

aagaagaaca ggaggggagg aagagaggac atcctggaga agtggatcac cacaagaagg 720

aaggccgagg agctggagaa ggacctgcgg aaggccagaa agaccatcaa gaagctggag 780

gatgaaaatc cttggctggg aaatatcatc ggaattatta gaaaaggcaa ggacggagag 840

ggagcacctc agcaaagcg gccaagaaca gaccagatgg agatcgattc tggaaccggc 900

aagaggcccc acaagagtgg cttcaccgat aaggagcgcg aggatcaccg ccggagaaag 960

gccctggaaa acaagaagaa gcaattaagc tccggcggca agaatctgag cagagaagaa 1020

gaggaggagc tgggccgcct gacagtggag gacgaggaga ggcgccggag agtggcagga 1080

cctagaaccg gcgatgtgaa cctgtccgga ggcggcccaa ggggagcacc tggaggcggc 1140

ttcgtgccac gcatggaggg cgtgcctgag tctcccttca ccaggacagg agagggcctg 1200

gacatcagag gcaatcaggg attcccatgg gtgcggccca gcccacctca gcagagactg 1260

cctctgctgg agtgtacccc acagggcaca aacctgtcca cctctaatcc tctgggcttc 1320

tttccagacc accagctgga tccagccttc agggccaact ccgccaaccc tgactgggac 1380

ttcaacccta ataaggacac atggccagat gccaacaagg tcggcggcca gaacctgagc 1440

acctccaatc ccctgggctt ctttcctgac caccagctgg atcccgcctt tcgcgccaat 1500

accgccaatc ccgactggga cttcaatcca aataaggaca cctggcccga tgctaacaaa 1560

gtgggatga 1569

<210> 23
<211> 1287
<212> DNA
<213> Artificial Sequence

<220>
<223> Delta-9 codon optimized DNA sequence

<400> 23
atggccagtc ggagcgaatc aaagaaaaat agaggggaa gagaagaaat cctggagcag 60

tgggtcgggg cacggaaaaa actggaagaa ctggagcggg acctgagaaa gatcaagaag 120

aagatcaaga agctggagga agagaacccc tggctgggca atatcaaggg catcctgggc 180

aagaaggata gggagggcga gggagcacca cctgcaaaga gggcaagggc agaccagatg 240

gaggtggatt ccggaccaag gaagcggccc ttccggggag agtttaccga caaggagcgg 300

agagatcaca ggcgccggaa ggccctggag aacaagcgga agcagctgag ctccggcggc 360

aagtctctga gcaaggagga ggaggaggag ctgagaaagc tgacagagga ggacgagaga 420

agggagagga gggtggcagg acctagggtg ggaggcgtga acccactgga gggaggaacc 480

aggggagcac ctggaggagg ctttgtgcca tctatgcagg gagtgccaga gagcccttc 540

gccaggacag gagagggcct ggatgtgcgc ggcaatcagg gcttcccctg ggacatcctg 600

tttcctgccg atccaccctt cagcccacag tcctgcaggc cacagtcccg ctctgagagc 660

aagaagaaca ggggaggaag ggaggaggtg ctggagcagt gggtgaatgg ccggaagaag 720

ctggaggagc tggagcggga gctgagaagg gccagaaaga agatcaagaa gctggaagac 780

gataatcctt ggctgggcaa tgtgaaaggc atcctgggca agaaggacaa ggatggagag 840

ggagcacctc cagcaaagag ggcacgcacc gaccagatgg agatcgattc tggacctagg 900

aagcggcccc tgagaggagg ctttacagac agggagcgcc aggatcaccg ccggagaaag 960

gccctgaaga acaagaagaa gcagctgagc gccggcggca agtccctgtc taaagaagag 1020

gaggaggagc tgaagcggct gaccagagag gacgaggagc ggaagaagga ggagcacgga 1080

ccatccagac tgggagtgaa tccttctgag ggaggaccaa gaggcgcccc aggcggcggc 1140

tttgtgccaa gcatgcaggg catccccgag tccaggttca ccagaaccgg cgaaggcctg 1200

gatgtgcggg gcagcagagg cttcccccag gatattctgt ttccctccga ccccccccttc 1260

agtccccagt cttgccgacc tcagtga 1287

<210> 24
<211> 1287
<212> DNA
<213> Artificial Sequence

<220>
<223> Delta-10 codon optimized DNA sequence

<400> 24
atggcctcac agagcgaaac acggcggggg cggaggggaa ctagagagga aacactggaa 60

aaatggatta cagcacggaa aaaggcagag gaactggaga aggacctgag gaagacccgc 120

aagacaatca agaagctgga ggaggagaac ccatggctgg gcaatatcgt gggcatcatc 180

cggaagggca aggatggaga gggagcacca cctgcaaaga ggccccgcac cgaccagatg 240

gaggtggatt ctggccctgg caagaggcca cacaagagcg gcttcacaga caaggagcgc 300

gaggatcacc ggagaaggaa ggccctggag aacaagaaga agcagctgag cgccggcggc 360

aagatcctgt ccaaggagga ggaggaggag ctgcgccggc tgaccgacga ggatgaggag 420

cggaagagaa gggtggcagg accaagagtg ggcgacgtga atccctctag gggaggacca 480

aggggagcac ctggaggagg cttcgtgcct cagatggcag gagtgccaga gtccccttt 540

tctaggaccg gagagggcct ggatatcagg ggaacacagg gctttccatg ggtgtctcca 600

agcccaccac agcagaggct gccactgctg gagtgcaccc ctcagtccca gtctgagagc 660

aagaagaaca ggaggggagg aagggaggac atcctggaga agtggatcac cacaagaagg 720

aaggccgagg agctggagaa ggacctgcgg aaggccagaa aaacaatcaa gaagctggaa 780

gatgagaacc cctggctggg caatatcatc ggcatcatca gaaaaggcaa ggacggcgag 840

ggagcacctc cagcaaagcg gcctagaacc gaccagatgg agatcgattc cggcacaggc 900

aagcggccac acaagtctgg cttcaccgac aaggagagag aggatcaccg ccggagaaag 960

gccctggaaa acaagaagaa gcaattaagc tccggcggca agaatctgag cagagaagaa 1020

gaggaggagc tgggcagact gaccgtggag gacgaggaga ggcgccggag agtggcagga 1080

cccagaacag gcgatgtgaa cctgagcgga ggaggaccta ggggagcacc aggaggcggc 1140

ttcgtgccta gaatggaggg cgtgccagag tccccttta ccaggacagg agagggcctg 1200

gacatcaggg gcaatcaggg ctttccctgg gtccgccctt caccaccaca gcagagactg 1260

cccctgctgg aatgcacacc acagtga 1287

<210> 25
<211> 1065
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-1 polypeptide sequence

<400> 25

Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1 5 10 15

Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
20 25 30

Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
35 40 45

Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
50 55 60

Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65 70 75 80

Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
85 90 95

Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
100 105 110

Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
115 120 125

Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
130 135 140

```
Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160

Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190

Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205

Pro Gln Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Gly Gly Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys
225                 230                 235                 240

Leu Glu Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys
                245                 250                 255

Lys Leu Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu
            260                 265                 270

Gly Lys Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu
    290                 295                 300

Arg Gly Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu
                325                 330                 335

Ser Lys Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu
            340                 345                 350

Glu Arg Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro
        355                 360                 365
```

```
Ser Glu Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser
    370                 375                 380

Met Gln Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400

Asp Val Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser
                405                 410                 415

Asp Pro Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Thr Asn Leu
            420                 425                 430

Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro
        435                 440                 445

Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn
    450                 455                 460

Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser
465                 470                 475                 480

Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala
                485                 490                 495

Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys
            500                 505                 510

Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Ser Gly Ala Thr Asn
        515                 520                 525

Phe Ser Leu Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro
    530                 535                 540

Met Ser Gln Ser Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg Glu Glu
545                 550                 555                 560

Thr Leu Glu Lys Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu Leu Glu
                565                 570                 575
```

```
Lys Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu Glu
            580                 585                 590

Asn Pro Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys Asp
        595                 600                 605

Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu
    610                 615                 620

Val Asp Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp
625                 630                 635                 640

Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys
                645                 650                 655

Lys Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu Glu
            660                 665                 670

Glu Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg Val
        675                 680                 685

Ala Gly Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro Arg
    690                 695                 700

Gly Ala Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro Glu
705                 710                 715                 720

Ser Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr Gln
                725                 730                 735

Gly Phe Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro Leu
            740                 745                 750

Leu Glu Cys Thr Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn Arg Arg
        755                 760                 765

Gly Gly Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg Lys
    770                 775                 780

Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile Lys
785                 790                 795                 800
```

```
Lys Leu Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly Ile Ile
               805                 810                 815

Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg
            820                 825                 830

Thr Asp Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro His Lys
        835                 840                 845

Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala
    850                 855                 860

Leu Glu Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn Leu Ser
865                 870                 875                 880

Arg Glu Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp Glu Glu
               885                 890                 895

Arg Arg Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn Leu Ser
            900                 905                 910

Gly Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Arg Met
        915                 920                 925

Glu Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly Leu Asp
    930                 935                 940

Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro Pro Gln
945                 950                 955                 960

Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln Gly Thr Asn Leu Ser
               965                 970                 975

Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala
            980                 985                 990

Phe Arg Ala Asn Ser Ala Asn Pro  Asp Trp Asp Phe Asn  Pro Asn Lys
        995                 1000                1005
```

Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser
    1010   1015   1020

Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro
    1025   1030   1035

Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro
    1040   1045   1050

Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
    1055   1060   1065

<210> 26
<211> 1065
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-2 polypeptide sequence

<400> 26

Met Ala Gly Thr Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro
1   5   10   15

Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp
            20   25   30

Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val
        35   40   45

Gly Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp
    50   55   60

His Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp
65   70   75   80

Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
                85   90   95

Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu Ile Leu
            100   105   110

```
Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu Arg Asp
        115                 120                 125

Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu Asn Pro
    130                 135                 140

Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg Glu Gly
145                 150                 155                 160

Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met Glu Val
                165                 170                 175

Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr Asp Lys
            180                 185                 190

Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Arg Lys
        195                 200                 205

Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu
    210                 215                 220

Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg Val Ala
225                 230                 235                 240

Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr Arg Gly
                245                 250                 255

Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro Glu Ser
            260                 265                 270

Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn Gln Gly
        275                 280                 285

Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser Pro Gln
    290                 295                 300

Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly
305                 310                 315                 320

Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys Leu Glu
                325                 330                 335
```

```
Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys Lys Leu
            340                 345                 350

Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu Gly Lys
        355                 360                 365

Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Thr
    370                 375                 380

Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu Arg Gly
385                 390                 395                 400

Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys Ala Leu
                405                 410                 415

Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu Ser Lys
            420                 425                 430

Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu Glu Arg
        435                 440                 445

Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro Ser Glu
    450                 455                 460

Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln
465                 470                 475                 480

Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu Asp Val
                485                 490                 495

Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser Asp Pro
            500                 505                 510

Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Ser Gly Ala Thr Asn
        515                 520                 525

Phe Ser Leu Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro
    530                 535                 540
```

```
Met Gly Thr Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp
545                 550                 555                 560

His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp
                565                 570                 575

Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
            580                 585                 590

Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His
        595                 600                 605

Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp
    610                 615                 620

Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Ser
625                 630                 635                 640

Gln Ser Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg Glu Glu Thr Leu
                645                 650                 655

Glu Lys Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu Leu Glu Lys Asp
            660                 665                 670

Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu Glu Asn Pro
        675                 680                 685

Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys Asp Gly Glu
    690                 695                 700

Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu Val Asp
705                 710                 715                 720

Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp Lys Glu
                725                 730                 735

Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys Gln
            740                 745                 750

Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu Glu Glu Leu
        755                 760                 765
```

```
Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg Val Ala Gly
    770                 775                 780

Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro Arg Gly Ala
785                 790                 795                 800

Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro Glu Ser Pro
                805                 810                 815

Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr Gln Gly Phe
            820                 825                 830

Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro Leu Leu Glu
        835                 840                 845

Cys Thr Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn Arg Arg Gly Gly
    850                 855                 860

Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg Lys Ala Glu
865                 870                 875                 880

Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile Lys Lys Leu
                885                 890                 895

Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly Ile Ile Arg Lys
            900                 905                 910

Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp
        915                 920                 925

Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro His Lys Ser Gly
    930                 935                 940

Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu
945                 950                 955                 960

Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn Leu Ser Arg Glu
                965                 970                 975
```

Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp Glu Glu Arg Arg
980 985 990

Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn Leu Ser Gly Gly
995 1000 1005

Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Arg Met Glu
1010 1015 1020

Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly Leu Asp
1025 1030 1035

Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro Pro
1040 1045 1050

Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln
1055 1060 1065

<210> 27
<211> 1253
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-3 polypeptide sequence

<400> 27

Met Ala Gly Thr Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro
1 5 10 15

Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp
20 25 30

Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val
35 40 45

Gly Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp
50 55 60

His Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp
65 70 75 80

```
Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
                85                  90                  95

Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu Ile Leu
            100                 105                 110

Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu Arg Asp
        115                 120                 125

Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu Asn Pro
    130                 135                 140

Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg Glu Gly
145                 150                 155                 160

Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met Glu Val
                165                 170                 175

Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr Asp Lys
            180                 185                 190

Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Arg Lys
        195                 200                 205

Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu
    210                 215                 220

Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg Val Ala
225                 230                 235                 240

Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr Arg Gly
                245                 250                 255

Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro Glu Ser
            260                 265                 270

Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn Gln Gly
        275                 280                 285

Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser Pro Gln
    290                 295                 300
```

```
Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly
305                 310                 315                 320

Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys Leu Glu
                325                 330                 335

Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys Lys Leu
            340                 345                 350

Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu Gly Lys
        355                 360                 365

Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Thr
    370                 375                 380

Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu Arg Gly
385                 390                 395                 400

Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys Ala Leu
                405                 410                 415

Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu Ser Lys
            420                 425                 430

Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu Glu Arg
        435                 440                 445

Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro Ser Glu
    450                 455                 460

Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln
465                 470                 475                 480

Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu Asp Val
                485                 490                 495

Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser Asp Pro
            500                 505                 510
```

```
Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Thr Asn Leu Ser Thr
        515                 520                 525

Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe
    530                 535                 540

Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp
545                 550                 555                 560

Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser Thr Ser
                565                 570                 575

Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg
            580                 585                 590

Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr
        595                 600                 605

Trp Pro Asp Ala Asn Lys Val Gly Gly Ser Gly Ala Thr Asn Phe Ser
    610                 615                 620

Leu Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro Met Gly
625                 630                 635                 640

Thr Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln
                645                 650                 655

Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe
            660                 665                 670

Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln
        675                 680                 685

Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu
    690                 695                 700

Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn
705                 710                 715                 720

Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Ser Gln Ser
                725                 730                 735
```

```
Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg Glu Glu Thr Leu Glu Lys
            740                 745                 750

Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg
        755                 760                 765

Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu Glu Asn Pro Trp Leu
    770                 775                 780

Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala
785                 790                 795                 800

Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu Val Asp Ser Gly
                805                 810                 815

Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu
            820                 825                 830

Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser
        835                 840                 845

Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu Glu Glu Leu Arg Arg
    850                 855                 860

Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg Val Ala Gly Pro Arg
865                 870                 875                 880

Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro Arg Gly Ala Pro Gly
                885                 890                 895

Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro Glu Ser Pro Phe Ser
            900                 905                 910

Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr Gln Gly Phe Pro Trp
        915                 920                 925

Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr
    930                 935                 940
```

```
Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn Arg Arg Gly Gly Arg Glu
945                 950                 955                 960


Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg Lys Ala Glu Glu Leu
                965                 970                 975


Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile Lys Lys Leu Glu Asp
            980                 985                 990


Glu Asn Pro Trp Leu Gly Asn Ile  Ile Gly Ile Ile Arg  Lys Gly Lys
        995                 1000                1005


Asp Gly  Glu Gly Ala Pro Pro  Ala Lys Arg Pro Arg  Thr Asp Gln
    1010                1015                1020


Met Glu  Ile Asp Ser Gly Thr  Gly Lys Arg Pro His  Lys Ser Gly
    1025                1030                1035


Phe Thr  Asp Lys Glu Arg Glu  Asp His Arg Arg Arg  Lys Ala Leu
    1040                1045                1050


Glu Asn  Lys Lys Lys Gln Leu  Ser Ser Gly Gly Lys  Asn Leu Ser
    1055                1060                1065


Arg Glu  Glu Glu Glu Glu Leu  Gly Arg Leu Thr Val  Glu Asp Glu
    1070                1075                1080


Glu Arg  Arg Arg Arg Val Ala  Gly Pro Arg Thr Gly  Asp Val Asn
    1085                1090                1095


Leu Ser  Gly Gly Gly Pro Arg  Gly Ala Pro Gly Gly  Gly Phe Val
    1100                1105                1110


Pro Arg  Met Glu Gly Val Pro  Glu Ser Pro Phe Thr  Arg Thr Gly
    1115                1120                1125


Glu Gly  Leu Asp Ile Arg Gly  Asn Gln Gly Phe Pro  Trp Val Arg
    1130                1135                1140


Pro Ser  Pro Pro Gln Gln Arg  Leu Pro Leu Leu Glu  Cys Thr Pro
    1145                1150                1155
```

```
Gln Gly  Thr Asn Leu Ser Thr  Ser Asn Pro Leu Gly  Phe Phe Pro
    1160                 1165                 1170


Asp His  Gln Leu Asp Pro Ala  Phe Arg Ala Asn Ser  Ala Asn Pro
    1175                 1180                 1185


Asp Trp  Asp Phe Asn Pro Asn  Lys Asp Thr Trp Pro  Asp Ala Asn
    1190                 1195                 1200


Lys Val  Gly Gly Gln Asn Leu  Ser Thr Ser Asn Pro  Leu Gly Phe
    1205                 1210                 1215


Phe Pro  Asp His Gln Leu Asp  Pro Ala Phe Arg Ala  Asn Thr Ala
    1220                 1225                 1230


Asn Pro  Asp Trp Asp Phe Asn  Pro Asn Lys Asp Thr  Trp Pro Asp
    1235                 1240                 1245


Ala Asn  Lys Val Gly
    1250


<210>  28
<211>  1299
<212>  PRT
<213>  Artificial Sequence

<220>
<223>  Delta-4 polypeptide sequence

<400>  28

Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1               5                   10                  15


Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
            20                  25                  30


Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
        35                  40                  45


Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
    50                  55                  60
```

```
Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65                  70                  75                  80

Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
                85                  90                  95

Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
            100                 105                 110

Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
        115                 120                 125

Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
    130                 135                 140

Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160

Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190

Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205

Pro Gln Ser Cys Arg Pro Gln Gly Thr Asn Leu Ser Thr Ser Asn Pro
    210                 215                 220

Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn
225                 230                 235                 240

Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro
                245                 250                 255

Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu
            260                 265                 270
```

```
Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr
        275                 280                 285

Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp
    290                 295                 300

Ala Asn Lys Val Gly Gly Ser Gly Ala Thr Asn Phe Ser Leu Leu Lys
305                 310                 315                 320

Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro Met Ser Arg Ser Glu
                325                 330                 335

Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu Val Leu Glu Gln Trp Val
            340                 345                 350

Asn Gly Arg Lys Lys Leu Glu Glu Leu Glu Arg Glu Leu Arg Arg Ala
        355                 360                 365

Arg Lys Lys Ile Lys Lys Leu Glu Asp Asp Asn Pro Trp Leu Gly Asn
    370                 375                 380

Val Lys Gly Ile Leu Gly Lys Lys Asp Lys Asp Gly Glu Gly Ala Pro
385                 390                 395                 400

Pro Ala Lys Arg Ala Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Pro
                405                 410                 415

Arg Lys Arg Pro Leu Arg Gly Gly Phe Thr Asp Arg Glu Arg Gln Asp
            420                 425                 430

His Arg Arg Arg Lys Ala Leu Lys Asn Lys Lys Lys Gln Leu Ser Ala
        435                 440                 445

Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu Leu Lys Arg Leu
    450                 455                 460

Thr Arg Glu Asp Glu Glu Arg Lys Lys Glu Glu His Gly Pro Ser Arg
465                 470                 475                 480

Leu Gly Val Asn Pro Ser Glu Gly Gly Pro Arg Gly Ala Pro Gly Gly
                485                 490                 495
```

```
Gly Phe Val Pro Ser Met Gln Gly Ile Pro Glu Ser Arg Phe Thr Arg
            500                 505                 510

Thr Gly Glu Gly Leu Asp Val Arg Gly Ser Arg Gly Phe Pro Gln Asp
        515                 520                 525

Ile Leu Phe Pro Ser Asp Pro Pro Phe Ser Pro Gln Ser Cys Arg Pro
    530                 535                 540

Gln Gly Thr Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp
545                 550                 555                 560

His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp
                565                 570                 575

Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
            580                 585                 590

Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His
        595                 600                 605

Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp
    610                 615                 620

Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly
625                 630                 635                 640

Ser Gly Ala Thr Asn Phe Ser Leu Leu Lys Gln Ala Gly Asp Val Glu
                645                 650                 655

Glu Asn Pro Gly Pro Met Ser Gln Ser Glu Thr Arg Arg Gly Arg Arg
            660                 665                 670

Gly Thr Arg Glu Glu Thr Leu Glu Lys Trp Ile Thr Ala Arg Lys Lys
        675                 680                 685

Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys
    690                 695                 700
```

```
Lys Leu Glu Glu Glu Asn Pro Trp Leu Gly Asn Ile Val Gly Ile Ile
705                 710                 715                 720


Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg
                725                 730                 735


Thr Asp Gln Met Glu Val Asp Ser Gly Pro Gly Lys Arg Pro His Lys
            740                 745                 750


Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala
        755                 760                 765


Leu Glu Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser
    770                 775                 780


Lys Glu Glu Glu Glu Glu Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu
785                 790                 795                 800


Arg Lys Arg Arg Val Ala Gly Pro Arg Val Gly Asp Val Asn Pro Ser
                805                 810                 815


Arg Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Gln Met
            820                 825                 830


Ala Gly Val Pro Glu Ser Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp
        835                 840                 845


Ile Arg Gly Thr Gln Gly Phe Pro Trp Val Ser Pro Ser Pro Pro Gln
    850                 855                 860


Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln Gly Thr Asn Leu Ser
865                 870                 875                 880


Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala
                885                 890                 895


Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys
            900                 905                 910


Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser Thr
        915                 920                 925
```

```
Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe
    930                 935                 940

Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp
945                 950                 955                 960

Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Ser Gly Ala Thr Asn Phe
                965                 970                 975

Ser Leu Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro Met
            980                 985                 990

Ser Gln Ser Glu Ser Lys Lys Asn  Arg Arg Gly Gly Arg  Glu Asp Ile
        995                 1000                1005

Leu Glu  Lys Trp Ile Thr Thr  Arg Arg Lys Ala Glu  Glu Leu Glu
    1010                1015                1020

Lys Asp  Leu Arg Lys Ala Arg  Lys Thr Ile Lys Lys  Leu Glu Asp
    1025                1030                1035

Glu Asn  Pro Trp Leu Gly Asn  Ile Ile Gly Ile Ile  Arg Lys Gly
    1040                1045                1050

Lys Asp  Gly Glu Gly Ala Pro  Pro Ala Lys Arg Pro  Arg Thr Asp
    1055                1060                1065

Gln Met  Glu Ile Asp Ser Gly  Thr Gly Lys Arg Pro  His Lys Ser
    1070                1075                1080

Gly Phe  Thr Asp Lys Glu Arg  Glu Asp His Arg Arg  Arg Lys Ala
    1085                1090                1095

Leu Glu  Asn Lys Lys Lys Gln  Leu Ser Ser Gly Gly  Lys Asn Leu
    1100                1105                1110

Ser Arg  Glu Glu Glu Glu Glu  Leu Gly Arg Leu Thr  Val Glu Asp
    1115                1120                1125
```

```
Glu Glu  Arg Arg Arg Arg Val  Ala Gly Pro Arg Thr  Gly Asp Val
    1130                1135                1140


Asn Leu  Ser Gly Gly Gly Pro  Arg Gly Ala Pro Gly  Gly Gly Phe
    1145                1150                1155


Val Pro  Arg Met Glu Gly Val  Pro Glu Ser Pro Phe  Thr Arg Thr
    1160                1165                1170


Gly Glu  Gly Leu Asp Ile Arg  Gly Asn Gln Gly Phe  Pro Trp Val
    1175                1180                1185


Arg Pro  Ser Pro Pro Gln Gln  Arg Leu Pro Leu Leu  Glu Cys Thr
    1190                1195                1200


Pro Gln  Gly Thr Asn Leu Ser  Thr Ser Asn Pro Leu  Gly Phe Phe
    1205                1210                1215


Pro Asp  His Gln Leu Asp Pro  Ala Phe Arg Ala Asn  Ser Ala Asn
    1220                1225                1230


Pro Asp  Trp Asp Phe Asn Pro  Asn Lys Asp Thr Trp  Pro Asp Ala
    1235                1240                1245


Asn Lys  Val Gly Gly Gln Asn  Leu Ser Thr Ser Asn  Pro Leu Gly
    1250                1255                1260


Phe Phe  Pro Asp His Gln Leu  Asp Pro Ala Phe Arg  Ala Asn Thr
    1265                1270                1275


Ala Asn  Pro Asp Trp Asp Phe  Asn Pro Asn Lys Asp  Thr Trp Pro
    1280                1285                1290


Asp Ala  Asn Lys Val Gly
    1295
```

<210> 29
<211> 877
<212> PRT
<213> Artificial Sequence

<220>

<223> Delta-5 polypeptide sequence

<400> 29

```
Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1               5                  10                  15


Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
            20                  25                  30


Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
        35                  40                  45


Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
    50                  55                  60


Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65                  70                  75                  80


Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
                85                  90                  95


Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
            100                 105                 110


Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
        115                 120                 125


Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
    130                 135                 140


Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160


Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175


Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190


Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205
```

```
Pro Gln Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Gly Gly Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys
225                 230                 235                 240

Leu Glu Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys
                245                 250                 255

Lys Leu Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu
            260                 265                 270

Gly Lys Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu
    290                 295                 300

Arg Gly Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu
                325                 330                 335

Ser Lys Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu
            340                 345                 350

Glu Arg Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro
        355                 360                 365

Ser Glu Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser
    370                 375                 380

Met Gln Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400

Asp Val Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser
                405                 410                 415
```

```
Asp Pro Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Ser Gly Ala
            420                 425                 430

Thr Asn Phe Ser Leu Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro
        435                 440                 445

Gly Pro Met Ser Gln Ser Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg
    450                 455                 460

Glu Glu Thr Leu Glu Lys Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu
465                 470                 475                 480

Leu Glu Lys Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu
                485                 490                 495

Glu Glu Asn Pro Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly
            500                 505                 510

Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln
        515                 520                 525

Met Glu Val Asp Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe
    530                 535                 540

Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn
545                 550                 555                 560

Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu
                565                 570                 575

Glu Glu Glu Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg
            580                 585                 590

Arg Val Ala Gly Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly
        595                 600                 605

Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val
    610                 615                 620

Pro Glu Ser Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly
625                 630                 635                 640
```

```
Thr Gln Gly Phe Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu
                645                 650                 655

Pro Leu Leu Glu Cys Thr Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn
            660                 665                 670

Arg Arg Gly Gly Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg
        675                 680                 685

Arg Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr
    690                 695                 700

Ile Lys Lys Leu Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly
705                 710                 715                 720

Ile Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg
                725                 730                 735

Pro Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro
            740                 745                 750

His Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg
        755                 760                 765

Lys Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn
    770                 775                 780

Leu Ser Arg Glu Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp
785                 790                 795                 800

Glu Glu Arg Arg Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn
                805                 810                 815

Leu Ser Gly Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro
            820                 825                 830

Arg Met Glu Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly
        835                 840                 845
```

```
Leu Asp Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro
    850                 855                 860


Pro Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln
865                 870                 875


<210>  30
<211>  923
<212>  PRT
<213>  Artificial Sequence

<220>
<223>  Delta-6 polypeptide sequence

<400>  30

Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1               5                   10                  15


Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
            20                  25                  30


Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
        35                  40                  45


Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
    50                  55                  60


Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65                  70                  75                  80


Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
                85                  90                  95


Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
            100                 105                 110


Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
        115                 120                 125


Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
    130                 135                 140
```

```
Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160

Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190

Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205

Pro Gln Ser Cys Arg Pro Gln Gly Ser Gly Ala Thr Asn Phe Ser Leu
    210                 215                 220

Leu Lys Gln Ala Gly Asp Val Glu Glu Asn Pro Gly Pro Met Ser Arg
225                 230                 235                 240

Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu Val Leu Glu Gln
                245                 250                 255

Trp Val Asn Gly Arg Lys Lys Leu Glu Glu Leu Glu Arg Glu Leu Arg
            260                 265                 270

Arg Ala Arg Lys Lys Ile Lys Lys Leu Glu Asp Asp Asn Pro Trp Leu
        275                 280                 285

Gly Asn Val Lys Gly Ile Leu Gly Lys Lys Asp Lys Asp Gly Glu Gly
    290                 295                 300

Ala Pro Pro Ala Lys Arg Ala Arg Thr Asp Gln Met Glu Ile Asp Ser
305                 310                 315                 320

Gly Pro Arg Lys Arg Pro Leu Arg Gly Gly Phe Thr Asp Arg Glu Arg
                325                 330                 335

Gln Asp His Arg Arg Arg Lys Ala Leu Lys Asn Lys Lys Lys Gln Leu
            340                 345                 350

Ser Ala Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu Leu Lys
        355                 360                 365
```

```
Arg Leu Thr Arg Glu Asp Glu Glu Arg Lys Lys Glu Glu His Gly Pro
    370                 375                 380

Ser Arg Leu Gly Val Asn Pro Ser Glu Gly Gly Pro Arg Gly Ala Pro
385                 390                 395                 400

Gly Gly Gly Phe Val Pro Ser Met Gln Gly Ile Pro Glu Ser Arg Phe
                405                 410                 415

Thr Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Ser Arg Gly Phe Pro
            420                 425                 430

Gln Asp Ile Leu Phe Pro Ser Asp Pro Pro Phe Ser Pro Gln Ser Cys
        435                 440                 445

Arg Pro Gln Gly Ser Gly Ala Thr Asn Phe Ser Leu Leu Lys Gln Ala
    450                 455                 460

Gly Asp Val Glu Glu Asn Pro Gly Pro Met Ser Gln Ser Glu Thr Arg
465                 470                 475                 480

Arg Gly Arg Arg Gly Thr Arg Glu Glu Thr Leu Glu Lys Trp Ile Thr
                485                 490                 495

Ala Arg Lys Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Thr Arg
            500                 505                 510

Lys Thr Ile Lys Lys Leu Glu Glu Glu Asn Pro Trp Leu Gly Asn Ile
        515                 520                 525

Val Gly Ile Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala
    530                 535                 540

Lys Arg Pro Arg Thr Asp Gln Met Glu Val Asp Ser Gly Pro Gly Lys
545                 550                 555                 560

Arg Pro His Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg
                565                 570                 575
```

```
Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly
            580                 585                 590

Lys Ile Leu Ser Lys Glu Glu Glu Glu Glu Leu Arg Arg Leu Thr Asp
        595                 600                 605

Glu Asp Glu Glu Arg Lys Arg Arg Val Ala Gly Pro Arg Val Gly Asp
    610                 615                 620

Val Asn Pro Ser Arg Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe
625                 630                 635                 640

Val Pro Gln Met Ala Gly Val Pro Glu Ser Pro Phe Ser Arg Thr Gly
                645                 650                 655

Glu Gly Leu Asp Ile Arg Gly Thr Gln Gly Phe Pro Trp Val Ser Pro
            660                 665                 670

Ser Pro Pro Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln Gly
        675                 680                 685

Ser Gly Ala Thr Asn Phe Ser Leu Leu Lys Gln Ala Gly Asp Val Glu
    690                 695                 700

Glu Asn Pro Gly Pro Met Ser Gln Ser Glu Ser Lys Lys Asn Arg Arg
705                 710                 715                 720

Gly Gly Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg Lys
                725                 730                 735

Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile Lys
            740                 745                 750

Lys Leu Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly Ile Ile
        755                 760                 765

Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg
    770                 775                 780

Thr Asp Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro His Lys
785                 790                 795                 800
```

Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala
805 810 815

Leu Glu Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn Leu Ser
820 825 830

Arg Glu Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp Glu Glu
835 840 845

Arg Arg Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn Leu Ser
850 855 860

Gly Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Arg Met
865 870 875 880

Glu Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly Leu Asp
885 890 895

Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro Pro Gln
900 905 910

Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln
915 920

<210> 31
<211> 522
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-7 polypeptide sequence

<400> 31

Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1 5 10 15

Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
20 25 30

Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
35 40 45

```
Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
    50                  55                  60

Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65                  70                  75                  80

Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
                85                  90                  95

Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
            100                 105                 110

Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
        115                 120                 125

Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
    130                 135                 140

Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160

Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190

Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205

Pro Gln Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Gly Gly Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys
225                 230                 235                 240

Leu Glu Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys
                245                 250                 255
```

```
Lys Leu Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu
            260                 265                 270

Gly Lys Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu
    290                 295                 300

Arg Gly Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu
                325                 330                 335

Ser Lys Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu
            340                 345                 350

Glu Arg Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro
        355                 360                 365

Ser Glu Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser
    370                 375                 380

Met Gln Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400

Asp Val Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser
                405                 410                 415

Asp Pro Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Thr Asn Leu
            420                 425                 430

Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro
        435                 440                 445

Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn
    450                 455                 460

Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser
465                 470                 475                 480
```

Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala
485 490 495

Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys
500 505 510

Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
515 520

<210> 32
<211> 522
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-8 polypeptide sequence

<400> 32

Met Ala Ser Gln Ser Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg Glu
1 5 10 15

Glu Thr Leu Glu Lys Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu Leu
20 25 30

Glu Lys Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu
35 40 45

Glu Asn Pro Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys
50 55 60

Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met
65 70 75 80

Glu Val Asp Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr
85 90 95

Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
100 105 110

Lys Lys Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu
115 120 125

```
Glu Glu Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg
    130                 135                 140

Val Ala Gly Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro
145                 150                 155                 160

Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr
            180                 185                 190

Gln Gly Phe Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro
        195                 200                 205

Leu Leu Glu Cys Thr Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Arg Gly Gly Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg
225                 230                 235                 240

Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile
                245                 250                 255

Lys Lys Leu Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly Ile
            260                 265                 270

Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro His
    290                 295                 300

Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn Leu
                325                 330                 335
```

```
Ser Arg Glu Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp Glu
            340                 345                 350

Glu Arg Arg Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn Leu
        355                 360                 365

Ser Gly Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Arg
    370                 375                 380

Met Glu Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400

Asp Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro Pro
                405                 410                 415

Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln Gly Thr Asn Leu
            420                 425                 430

Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro
        435                 440                 445

Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn
    450                 455                 460

Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser
465                 470                 475                 480

Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala
                485                 490                 495

Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys
            500                 505                 510

Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
        515                 520
```

<210> 33
<211> 428
<212> PRT
<213> Artificial Sequence

<220>

<223> Delta-9 polypeptide sequence

<400> 33

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Met Ala Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu
1               5                  10                  15


Ile Leu Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu
            20                  25                  30


Arg Asp Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu
        35                  40                  45


Asn Pro Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg
    50                  55                  60


Glu Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met
65                  70                  75                  80


Glu Val Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr
                85                  90                  95


Asp Lys Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
            100                 105                 110


Arg Lys Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu
        115                 120                 125


Glu Glu Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg
    130                 135                 140


Val Ala Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr
145                 150                 155                 160


Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro
                165                 170                 175


Glu Ser Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn
            180                 185                 190


Gln Gly Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser
        195                 200                 205
```

```
Pro Gln Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Gly Gly Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys
225                 230                 235                 240

Leu Glu Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys
                245                 250                 255

Lys Leu Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu
            260                 265                 270

Gly Lys Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu
    290                 295                 300

Arg Gly Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu
                325                 330                 335

Ser Lys Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu
            340                 345                 350

Glu Arg Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro
        355                 360                 365

Ser Glu Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser
    370                 375                 380

Met Gln Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400

Asp Val Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser
                405                 410                 415
```

Asp Pro Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln
420 425

<210> 34
<211> 428
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-10 polypeptide sequence

<400> 34

Met Ala Ser Gln Ser Glu Thr Arg Arg Gly Arg Arg Gly Thr Arg Glu
1 5 10 15

Glu Thr Leu Glu Lys Trp Ile Thr Ala Arg Lys Lys Ala Glu Glu Leu
20 25 30

Glu Lys Asp Leu Arg Lys Thr Arg Lys Thr Ile Lys Lys Leu Glu Glu
35 40 45

Glu Asn Pro Trp Leu Gly Asn Ile Val Gly Ile Ile Arg Lys Gly Lys
50 55 60

Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met
65 70 75 80

Glu Val Asp Ser Gly Pro Gly Lys Arg Pro His Lys Ser Gly Phe Thr
85 90 95

Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys
100 105 110

Lys Lys Gln Leu Ser Ala Gly Gly Lys Ile Leu Ser Lys Glu Glu Glu
115 120 125

Glu Glu Leu Arg Arg Leu Thr Asp Glu Asp Glu Glu Arg Lys Arg Arg
130 135 140

Val Ala Gly Pro Arg Val Gly Asp Val Asn Pro Ser Arg Gly Gly Pro
145 150 155 160

```
Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Gln Met Ala Gly Val Pro
                165                 170                 175

Glu Ser Pro Phe Ser Arg Thr Gly Glu Gly Leu Asp Ile Arg Gly Thr
            180                 185                 190

Gln Gly Phe Pro Trp Val Ser Pro Ser Pro Pro Gln Gln Arg Leu Pro
        195                 200                 205

Leu Leu Glu Cys Thr Pro Gln Ser Gln Ser Glu Ser Lys Lys Asn Arg
    210                 215                 220

Arg Gly Gly Arg Glu Asp Ile Leu Glu Lys Trp Ile Thr Thr Arg Arg
225                 230                 235                 240

Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Ala Arg Lys Thr Ile
                245                 250                 255

Lys Lys Leu Glu Asp Glu Asn Pro Trp Leu Gly Asn Ile Ile Gly Ile
            260                 265                 270

Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Pro
        275                 280                 285

Arg Thr Asp Gln Met Glu Ile Asp Ser Gly Thr Gly Lys Arg Pro His
    290                 295                 300

Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg Lys
305                 310                 315                 320

Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser Ser Gly Gly Lys Asn Leu
                325                 330                 335

Ser Arg Glu Glu Glu Glu Glu Leu Gly Arg Leu Thr Val Glu Asp Glu
            340                 345                 350

Glu Arg Arg Arg Arg Val Ala Gly Pro Arg Thr Gly Asp Val Asn Leu
        355                 360                 365

Ser Gly Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Arg
    370                 375                 380
```

```
Met Glu Gly Val Pro Glu Ser Pro Phe Thr Arg Thr Gly Glu Gly Leu
385                 390                 395                 400


Asp Ile Arg Gly Asn Gln Gly Phe Pro Trp Val Arg Pro Ser Pro Pro
                405                 410                 415


Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln
            420                 425


<210>  35
<211>  3434
<212>  DNA
<213>  Artificial Sequence

<220>
<223>  Wild-type Delta-7/Delta-8 fusion nucleic acid sequence

<400>  35
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atcatcagct ggatccggcg tttcgcgcga acagcgcgaa cccggattgg gattttaacc      120

cgaacaaaga tacctggccg gatgcgaaca aagtgggcgg ccagaacctg agcaccagca      180

acccgctggg ctttttttccg gatcatcagc tggatccggc gtttcgcgcg aacaccgcga      240

acccggattg ggattttaac ccgaacaaag atacctggcc ggatgcgaac aaagtgggca      300

gccgcagcga aagcaaaaaa aaccgcggcg gccgcgaaga aattctggaa cagtgggtgg      360

gcgcgcgcaa aaaactggaa gaactggaac gcgatctgcg caaaattaaa aaaaaaatta      420

aaaaactgga agaagaaaac ccgtggctgg gcaacattaa aggcattctg ggcaaaaaag      480

atcgcgaagg cgaaggcgcg ccgccggcga aacgcgcgcg cgcggatcag atggaagtgg      540

atagcggccc gcgcaaacgc ccgtttcgcg gcgaatttac cgataaagaa cgccgcgatc      600

atcgccgccg caaagcgctg gaaaacaaac gcaaacagct gagcagcggc ggcaaaagcc      660

tgagcaaaga agaagaagaa gaactgcgca aactgaccga agaagatgaa cgccgcgaac      720

gccgcgtggc gggcccgcgc gtgggcggcg tgaacccgct ggaaggcggc acccgcggcg      780

cgccgggcgg cggctttgtg ccgagcatgc agggcgtgcc ggaaagcccg tttgcgcgca      840

ccggcgaagg cctggatgtg cgcggcaacc agggctttcc gtgggatatt ctgtttccgg      900

cggatccgcc gtttagcccg cagagctgcc gcccgcagag ccgcagcgaa agcaaaaaaa      960
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accgcggcgg ccgcgaagaa gtgctggaac agtgggtgaa cggccgcaaa aaactggaag 1020

aactggaacg cgaactgcgc cgcgcgcgca aaaaaattaa aaaactggaa gatgataacc 1080

cgtggctggg caacgtgaaa ggcattctgg gcaaaaaaga taaagatggc gaaggcgcgc 1140

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cgctgcgcgg cggctttacc gatcgcgaac gccaggatca tcgccgccgc aaagcgctga 1260

aaaacaaaaa aaaacagctg agcgcgggcg gcaaaagcct gagcaaagaa gaagaagaag 1320

aactgaaacg cctgacccgc gaagatgaag aacgcaaaaa agaagaacat ggcccgagcc 1380

gcctgggcgt gaacccgagc gaaggcggcc cgcgcggcgc gccgggcggc ggctttgtgc 1440

cgagcatgca gggcattccg gaaagccgct ttacccgcac cggcgaaggc ctggatgtgc 1500

gcggcagccg cggctttccg caggatattc tgtttccgag cgatccgccg tttagcccgc 1560

agagctgccg cccgcagggc accaacctga gcaccagcaa cccgctgggc ttttttccgg 1620

atcatcagct ggatccggcg tttcgcgcga acagcgcgaa cccggattgg gattttaacc 1680

cgaacaaaga tacctggccg gatgcgaaca aagtgggcgg ccagaacctg agcaccagca 1740

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gccagagcga aacccgccgc ggccgccgcg gcacccgcga agaaaccctg gaaaaatgga 1920

ttaccgcgcg caaaaaagcg gaagaactgg aaaaagatct gcgcaaaacc cgcaaaacca 1980

ttaaaaaact ggaagaagaa aacccgtggc tgggcaacat tgtgggcatt attcgcaaag 2040

gcaaagatgg cgaaggcgcg ccgccggcga aacgcccgcg caccgatcag atggaagtgg 2100

atagcggccc gggcaaacgc ccgcataaaa gcggctttac cgataaagaa cgcgaagatc 2160

atcgccgccg caaagcgctg gaaaacaaaa aaaaacagct gagcgcgggc ggcaaaattc 2220

tgagcaaaga agaagaagaa gaactgcgcc gcctgaccga tgaagatgaa gaacgcaaac 2280

gccgcgtggc gggcccgcgc gtgggcgatg tgaacccgag ccgcggcggc ccgcgcggcg 2340

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accgccgcgg cggccgcgaa gatattctgg aaaaatggat taccacccgc cgcaaagcgg 2580

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cgaacaaaga tacctggccg gatgcgaaca aagtgggcgg ccagaacctg agcaccagca 3300

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gatgagaatt ccgt 3434

<210> 36
<211> 3431
<212> DNA
<213> Artificial Sequence

<220>
<223> Codon optimized Delta-7/Delta-8 fusion nucleic acid sequence

<400> 36
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accatcagct ggaccccgca ttccgagcaa actccgctaa ccctgactgg gatttcaacc 120

caaataagga cacctggccc gatgccaata aggtcggcgg ccagaacctg tccacatcta 180

atccactggg cttctttccc gaccaccagc tggatcctgc cttccgggcc aacacagcca 240

atcctgactg ggacttcaac cctaataagg atacctggcc cgatgccaac aaggtcggca 300

gcaggtccga gtctaagaag aataggggag gaagggagga gatcctggag cagtgggtgg 360

gagcacgcaa gaagctggag gagctggagc gggacctgag aaagatcaag aagaagatca 420

agaagctgga ggaggagaac ccctggctgg gcaatatcaa gggcatcctg ggcaagaagg 480

atcgggaggg agagggagca ccacctgcaa agagggccag agccgaccag atggaggtgg 540

attccggccc taggaagcgc ccattcagag gcgagtttac cgacaaggag cggagagatc 600

acaggcgccg gaaggccctg gagaacaagc ggaagcagct gagctccggc ggcaagagcc 660

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cacctggagg aggattcgtg ccatccatgc agggagtgcc tgagtctcca tttgccagga 840

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ccgatccacc cttctcccct cagtcttgca ggccacagtc tcgcagcgag tccaagaaga 960

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cttggctggg caatgtgaaa ggcatcctgg gcaagaagga caaggatgga gagggagcac 1140

ctccagcaaa gagggcaaga accgaccaga tggagatcga ttctggacca aggaagcgcc 1200

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agaacaagaa gaagcagctg agcgccggcg gcaagtctct gagtaaagaa gaagaggagg 1320

agctgaagcg gctgaccaga gaggacgagg agcggaagaa ggaggagcac ggaccaagca 1380

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atcccgactg ggacttcaac ccaaataagg acacgtggcc agacgcaaac aaggtcggct 1860

ctcagagcga gacaaggagg ggccggagag gaaccaggga ggagacactg gagaagtgga 1920

tcaccgccag aaagaaggcc gaggagctgg agaaggacct gaggaagacc cgcaagacaa 1980

tcaagaagct ggaagaagag aacccatggc tgggcaatat cgtgggcatc atccgcaagg 2040

gcaaggacgg cgagggagca ccaccagcaa agaggcccag gactgatcag atggaggtgg 2100

atagcggccc tggcaagagg ccacacaagt ccggcttcac agacaaggag agggaggacc 2160

ataggcgccg gaaggccctg gaaaacaaga agaagcaatt atccgccggc ggcaagatcc 2220

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acagaagggg cggcagagag gacatcctgg aaaaatggat caccacacgc agaaaagctg 2580

aagaactgga aaaggacctg cggaaggcca gaaaaacaat caagaagctg gaggatgaaa 2640

atccatggct gggaaacatc atcggcatca tcagaaaggg caaggacggg gaaggcgcac 2700

cacctgcaaa gcggcctaga acagatcaga tggaaatcga ttctggaacc ggcaagcggc 2760

cacacaagag cggcttcacc gacaaggaga gagaggatca cagaaggcgc aaggccctgg 2820

agaacaagaa gaagcaatta agcagcggcg gcaagaatct gtccagagaa gaggaagagg 2880

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ctaataagga cacctggcca gatgcaaaca aggtcggcgg ccaaaacctg tctacaagca 3300

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<210> 37
<211> 1136
<212> PRT
<213> Artificial Sequence

<220>
<223> Delta-7/Delta-8 fusion polypeptide sequence

<400> 37

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Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser Ala Asn Pro Asp
            20                  25                  30


Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val
        35                  40                  45


Gly Gly Gln Asn Leu Ser Thr Ser Asn Pro Leu Gly Phe Phe Pro Asp
    50                  55                  60


His Gln Leu Asp Pro Ala Phe Arg Ala Asn Thr Ala Asn Pro Asp Trp
65                  70                  75                  80


Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro Asp Ala Asn Lys Val Gly
                85                  90                  95


Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly Arg Glu Glu Ile Leu
            100                 105                 110


Glu Gln Trp Val Gly Ala Arg Lys Lys Leu Glu Glu Leu Glu Arg Asp
        115                 120                 125


Leu Arg Lys Ile Lys Lys Lys Ile Lys Lys Leu Glu Glu Glu Asn Pro
    130                 135                 140


Trp Leu Gly Asn Ile Lys Gly Ile Leu Gly Lys Lys Asp Arg Glu Gly
145                 150                 155                 160


Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Ala Asp Gln Met Glu Val
                165                 170                 175


Asp Ser Gly Pro Arg Lys Arg Pro Phe Arg Gly Glu Phe Thr Asp Lys
            180                 185                 190
```

```
Glu Arg Arg Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Arg Lys
        195                 200                 205

Gln Leu Ser Ser Gly Gly Lys Ser Leu Ser Lys Glu Glu Glu Glu Glu
    210                 215                 220

Leu Arg Lys Leu Thr Glu Glu Asp Glu Arg Arg Glu Arg Arg Val Ala
225                 230                 235                 240

Gly Pro Arg Val Gly Gly Val Asn Pro Leu Glu Gly Gly Thr Arg Gly
                245                 250                 255

Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln Gly Val Pro Glu Ser
            260                 265                 270

Pro Phe Ala Arg Thr Gly Glu Gly Leu Asp Val Arg Gly Asn Gln Gly
        275                 280                 285

Phe Pro Trp Asp Ile Leu Phe Pro Ala Asp Pro Pro Phe Ser Pro Gln
    290                 295                 300

Ser Cys Arg Pro Gln Ser Arg Ser Glu Ser Lys Lys Asn Arg Gly Gly
305                 310                 315                 320

Arg Glu Glu Val Leu Glu Gln Trp Val Asn Gly Arg Lys Lys Leu Glu
                325                 330                 335

Glu Leu Glu Arg Glu Leu Arg Arg Ala Arg Lys Lys Ile Lys Lys Leu
            340                 345                 350

Glu Asp Asp Asn Pro Trp Leu Gly Asn Val Lys Gly Ile Leu Gly Lys
        355                 360                 365

Lys Asp Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg Ala Arg Thr
    370                 375                 380

Asp Gln Met Glu Ile Asp Ser Gly Pro Arg Lys Arg Pro Leu Arg Gly
385                 390                 395                 400

Gly Phe Thr Asp Arg Glu Arg Gln Asp His Arg Arg Arg Lys Ala Leu
                405                 410                 415
```

```
Lys Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ser Leu Ser Lys
            420                 425                 430

Glu Glu Glu Glu Glu Leu Lys Arg Leu Thr Arg Glu Asp Glu Glu Arg
        435                 440                 445

Lys Lys Glu Glu His Gly Pro Ser Arg Leu Gly Val Asn Pro Ser Glu
    450                 455                 460

Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro Ser Met Gln
465                 470                 475                 480

Gly Ile Pro Glu Ser Arg Phe Thr Arg Thr Gly Glu Gly Leu Asp Val
                485                 490                 495

Arg Gly Ser Arg Gly Phe Pro Gln Asp Ile Leu Phe Pro Ser Asp Pro
            500                 505                 510

Pro Phe Ser Pro Gln Ser Cys Arg Pro Gln Gly Thr Asn Leu Ser Thr
        515                 520                 525

Ser Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe
    530                 535                 540

Arg Ala Asn Ser Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp
545                 550                 555                 560

Thr Trp Pro Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser Thr Ser
                565                 570                 575

Asn Pro Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg
            580                 585                 590

Ala Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr
        595                 600                 605

Trp Pro Asp Ala Asn Lys Val Gly Ser Gln Ser Glu Thr Arg Arg Gly
    610                 615                 620
```

```
Arg Arg Gly Thr Arg Glu Glu Thr Leu Glu Lys Trp Ile Thr Ala Arg
625                 630                 635                 640

Lys Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg Lys Thr Arg Lys Thr
                645                 650                 655

Ile Lys Lys Leu Glu Glu Glu Asn Pro Trp Leu Gly Asn Ile Val Gly
            660                 665                 670

Ile Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala Pro Pro Ala Lys Arg
        675                 680                 685

Pro Arg Thr Asp Gln Met Glu Val Asp Ser Gly Pro Gly Lys Arg Pro
    690                 695                 700

His Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu Asp His Arg Arg Arg
705                 710                 715                 720

Lys Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser Ala Gly Gly Lys Ile
                725                 730                 735

Leu Ser Lys Glu Glu Glu Glu Glu Leu Arg Arg Leu Thr Asp Glu Asp
            740                 745                 750

Glu Glu Arg Lys Arg Arg Val Ala Gly Pro Arg Val Gly Asp Val Asn
        755                 760                 765

Pro Ser Arg Gly Gly Pro Arg Gly Ala Pro Gly Gly Gly Phe Val Pro
    770                 775                 780

Gln Met Ala Gly Val Pro Glu Ser Pro Phe Ser Arg Thr Gly Glu Gly
785                 790                 795                 800

Leu Asp Ile Arg Gly Thr Gln Gly Phe Pro Trp Val Ser Pro Ser Pro
                805                 810                 815

Pro Gln Gln Arg Leu Pro Leu Leu Glu Cys Thr Pro Gln Ser Gln Ser
            820                 825                 830

Glu Ser Lys Lys Asn Arg Arg Gly Gly Arg Glu Asp Ile Leu Glu Lys
        835                 840                 845
```

```
Trp Ile Thr Thr Arg Arg Lys Ala Glu Glu Leu Glu Lys Asp Leu Arg
    850                 855                 860

Lys Ala Arg Lys Thr Ile Lys Lys Leu Glu Asp Glu Asn Pro Trp Leu
865                 870                 875                 880

Gly Asn Ile Ile Gly Ile Ile Arg Lys Gly Lys Asp Gly Glu Gly Ala
                885                 890                 895

Pro Pro Ala Lys Arg Pro Arg Thr Asp Gln Met Glu Ile Asp Ser Gly
            900                 905                 910

Thr Gly Lys Arg Pro His Lys Ser Gly Phe Thr Asp Lys Glu Arg Glu
        915                 920                 925

Asp His Arg Arg Arg Lys Ala Leu Glu Asn Lys Lys Lys Gln Leu Ser
    930                 935                 940

Ser Gly Gly Lys Asn Leu Ser Arg Glu Glu Glu Glu Glu Leu Gly Arg
945                 950                 955                 960

Leu Thr Val Glu Asp Glu Glu Arg Arg Arg Arg Val Ala Gly Pro Arg
                965                 970                 975

Thr Gly Asp Val Asn Leu Ser Gly Gly Gly Pro Arg Gly Ala Pro Gly
            980                 985                 990

Gly Gly Phe Val Pro Arg Met Glu  Gly Val Pro Glu Ser  Pro Phe Thr
        995                 1000                1005

Arg Thr  Gly Glu Gly Leu Asp  Ile Arg Gly Asn Gln  Gly Phe Pro
    1010                1015                1020

Trp Val  Arg Pro Ser Pro Pro  Gln Gln Arg Leu Pro  Leu Leu Glu
    1025                1030                1035

Cys Thr  Pro Gln Gly Thr Asn  Leu Ser Thr Ser Asn  Pro Leu Gly
    1040                1045                1050
```

Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg Ala Asn Ser
    1055   1060   1065

Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr Trp Pro
    1070   1075   1080

Asp Ala Asn Lys Val Gly Gly Gln Asn Leu Ser Thr Ser Asn Pro
    1085   1090   1095

Leu Gly Phe Phe Pro Asp His Gln Leu Asp Pro Ala Phe Arg Ala
    1100   1105   1110

Asn Thr Ala Asn Pro Asp Trp Asp Phe Asn Pro Asn Lys Asp Thr
    1115   1120   1125

Trp Pro Asp Ala Asn Lys Val Gly
    1130   1135

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<211> 8
<212> PRT
<213> Artificial Sequence

<220>
<223> Ovalbumin 257-264 CTL

<400> 38

Ser Ile Ile Asn Phe Glu Lys Leu
1   5

<210> 39
<211> 17
<212> PRT
<213> Artificial Sequence

<220>
<223> Ovalbumin 323-339 Th

<400> 39

Ile Ser Gln Ala Val His Ala Ala His Ala Glu Ile Asn Glu Ala Gly
1   5   10   15

Arg