about 50 nm, or from about 20 nm to about 40 nm, or from about 15 nm to about 50 nn, or from about 15 nm to about 40 nm, or from about 15 nm to about 35 nm, or from about 15 nm to about 30 nm, or from about 15 nm to about 25 nm, or alternatively about 15 nm, or about 20 nm, or about 25 nm, or about 30 nm, or about 35 nm, or about 40 nm. In some aspects, the nanoparticle core further comprises an outer coating or layer, wherein the diameter of the core and outer layer have an average diameter of from about 30 nm to about 75 nm, or from about 30 nm to about 70 nm, or from about 30 nm to about 60 nm, or from about 30 nm to about 50 nm, or about 40 nm. In some aspects, the nanoparticle has an average pMHC density of from about 0.4 pMHC/100 nm^2 to about 12 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 11.6 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 11.5 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 11 pMHC/100 nm^2,or from about 0.4 pMHC/100 nm^2 to about 10 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 9 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 8 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 7 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 6 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 5 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 4 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 3 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 2.5 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 2 pMHC/100 nm^2, or from about 0.4 pMHC/100 nm^2 to about 1.5 pMHC/100 nm^2.

[0017] Further aspects of the disclosure relate to methods to treat or prevent the relevant disease or conditions as disclosed herein by admininstering an effective amount of a pMHC-NP as disclosed herein. Also disclosed are methods of detecting the presence and efficacy of treatment with the pMHC-NP complexes and compositions as disclosed herein.

[0017a] This disclosure also provides a complex comprising a nanoparticle core coupled to a plurality of autoimmune disease/inflammation-relevant antigen-MHC class II (pMHCII) complexes, wherein the nanoparticle core comprises a metal or metal oxide and has a diameter from about 1 nm to about 100 nm; wherein the autoimmune disease-relevant pMHCII density per nanoparticle is from about 0.4 pMHC/100 nm^2 to about 15 pMHC/100 nm^2 of the surface area of the nanoparticle.

[0017b] This disclosure also provides a use of the complex as disclosure herein or the composition as disclosed herein in the manufacture of a medicament for treating pre-diabetes, multiple sclerosis, allergic asthma, primary biliary cirrhosis, cirrhosis, Neuromyelitis optica

spectrum disorder (Devic's disease, NMO), autoimmune encephalitis, autoantibody-mediated neurological syndromes, a Stiff Man syndrome, paraneoplastic disease, other diseases of the central and peripheral nervous systems, Pemphigus vulgaris, inflammatory bowel disease, Crohn's disease, Ulcerative Colitis, arthritis, Rheumatoid Arthritis, systemic lupus erythematosus (SLE), Celiac Disease, psoriasis, Alopecia Areata, Acquired Thrombocytopenic Purpura, autoimmune cardiomyopathy, idiopathic dilated cardiomyopathy (IDCM), Myasthenia Gravis, Uveitis, Ankylosing Spondylitis, Grave's Disease, Hashimoto's thyroiditis, Immune Mediated Myopathies, anti-phospholipid syndrome (ANCA+), atherosclerosis, scleroderma, autoimmune hepatitis, dermatomyositis, chronic obstructive pulmonary disease, a spinal cord injury, traumatic injury, tobacco-induced lung destruction, Chronic Obstructive Pulmonary Disease (COPD), lung emphysema, sclerosing cholangitis, peripheral neuropathy, narcolepsy, Goodpasture Syndrome, Kawasaki´s Disease, autoimmune uveitis, colitis, emphysema, pemphigus, pemphigus folliaceus, Sjogren's Syndrome, ANCA-associated vasculitis, primary sclerosing cholangitis-relevant antigen, adipose tissue inflammation/diabetes type II, or obesity associated adipose tissue inflammation/insulin resistance.

[0017c] This disclosure also provides a complex comprising a nanoparticle core coupled to a plurality of type I diabetes-relevant antigen-MHC class II (pMHCII) complexes, wherein the nanoparticle core comprises a metal or metal oxide and has a diameter from about 1 nm to about 100 nm; wherein the type I diabetes-relevant pMHCII density per nanoparticle is from about 0.4 pMHC/100 nm^2 to about 15 pMHC/100 nm^2 of the surface area of the nanoparticle.

[0017d] This disclosure also provides a method for differentiating an activated T cell or a memory T cell into a IL-10 producing T_R1 cell, the method comprising contacting the activated T cell or memory T cell with an effective amount of the complex as disclosed herein.

[0017e] This disclosure also provides a use of the complex as disclosed herein or the composition as disclosed herein for the manufacture of a medicament for treating Type 1 diabetes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The following drawings form part of the present specification and are included to further demonstrate certain aspects of the present disclosure. The disclosure may be better understood by reference to one or more of these drawings in combination with the detailed description of specific embodiments presented herein.

[0019] **FIGS. 1A-1B** show schematics of NP-complexes. **FIG. 1A** is a schematic of a single-chain pMHC-class I expression construct (top) and a representative flow cytometric profile of the binding of the corresponding pMHC tetramer (fluorochrome-labeled) to cognate CD8+ T-cells. **FIG. 1B** is a schematic showing the linkers and two dimensional

What is claimed is:

1. A complex comprising a nanoparticle core coupled to a plurality of autoimmune disease/inflammation-relevant antigen-MHC class II (pMHCII) complexes, wherein the nanoparticle core comprises a metal or metal oxide and has a diameter from about 1 nm to about 100 nm; wherein the autoimmune disease-relevant pMHCII density per nanoparticle is from about 0.4 pMHC/100 nm^2 to about 15 pMHC/100 nm^2 of the surface area of the nanoparticle.

2. The complex of claim 1, wherein the MHCII molecule of the plurality of pMHCII complexes comprises HLA DR, HLA DQ, HLA DP, or a fragment thereof.

3. The complex of claim 2, wherein the MHCII molecule of the plurality of pMHCII complexes comprises HLA-DRB1/DRA, HLA-DRB3/DRA, HLA-DRB4/DRA, HLA-DRB5/DRA, HLA-DQA1/HLA-DQB1, HLA-DPB1/HLA-DPA1, or a fragment thereof.

4. The complex of any one of claims 1 to 3, wherein the complex further comprises an outer layer.

5. The complex of any one of claims 1 to 4, wherein the valency of the plurality of pMHCII complexes per nanoparticle core is from about 10:1 to about 100:1.

6. The complex of any one of claims 1 to 5, wherein the nanoparticle core comprises a diameter from about 5 nm to about 50 nm.

7. The complex of any one of claims 1 to 6, wherein the autoimmune disease/inflammation-relevant antigen is selected from the group consisting of: an asthma-relevant antigen, a diabetes-relevant antigen, a pre-diabetes relevant antigen, a multiple sclerosis-relevant antigen, an allergic asthma-relevant antigen, a primary biliary cirrhosis-relevant antigen, a cirrhosis-relevant antigen, a Neuromyelitis optica spectrum disorder (Devic's disease, NMO)-relevant antigen, an autoimmune encephalitis-relevant antigen, an antigen relevant to autoantibody-mediated neurological syndromes, a Stiff Man syndrome-relevant antigen, a paraneoplastic disease-relevant antigen, antigens relevant to other diseases of the central and peripheral nervous systems, a Pemphigus vulgaris-relevant antigen, inflammatory bowel disease (IBD)-relevant antigen, Crohn's disease-relevant antigen, Ulcerative Colitis-relevant antigen, an arthritis-relevant antigen, a Rheumatoid Arthritis-relevant antigen, a systemic lupus erythematosus (SLE)-relevant antigen, a Celiac Disease relevant antigen, a psoriasis-relevant antigen, an Alopecia Areata-relevant antigen, an

Acquired Thrombocytopenic Purpura-relevant antigen, an autoimmune cardiomyopathy-relevant antigen, an idiopathic dilated cardiomyopathy (IDCM)-relevant antigen, a Myasthenia Gravis-relevant antigen, an Uveitis-relevant antigen, an Ankylosing Spondylitis-relevant antigen, a Grave's Disease-relevant antigen, a Hashimoto's thyroiditis-relevant antigen, an Immune Mediated Myopathies-relevant antigen, an anti-phospholipid syndrome (ANCA+)-relevant antigen, an atherosclerosis-relevant antigen, a scleroderma-relevant antigen, an autoimmune hepatitis-relevant antigen, a dermatomyositis-relevant antigen, a chronic obstructive pulmonary disease-relevant antigen, a spinal cord injury-relevant antigen, a traumatic injury-relevant antigen, a tobacco-induced lung destruction-relevant antigen, a Chronic Obstructive Pulmonary Disease (COPD)-relevant antigen, a lung emphysema-relevant antigen, a sclerosing cholangitis-relevant antigen, a peripheral neuropathy-relevant antigen, a narcolepsy-relevant antigen, a Goodpasture Syndrome-relevant antigen, a Kawasaki's Disease-relevant antigen, an autoimmune uveitis-relevant antigen, a colitis-relevant antigen, , an emphysema-relevant antigen, a pemphigus-relevant antigen, a pemphigus folliaceus-relevant antigen, an arthritis-relevant antigen, a Sjogren's Syndrome-relevant antigen, an ANCA-associated vasculitis-relevant antigen, a primary sclerosing cholangitis-relevant antigen, an adipose tissue inflammation/diabetes type II-relevant antigen, and an obesity associated adipose tissue inflammation/insulin resistance-relevant antigen.

8. The complex of any one of claims 1 to 7, wherein the pMHCII complex is covalently coupled to the nanoparticle core by a linker.

9. The complex of claim 8, wherein the linker is less than 5 kD in size.

10. The complex of claim 8, wherein the linker comprises polyethylene glycol.

11. The complex of claim 8, wherein the linker is maleimide functionalized.

12. The complex of any one of claims 1 to 11, wherein the complex differentiates an activated or memory T cell into a IL-10 producing T_R1 cell.

13. A composition comprising a plurality of complexes of any of claims 1 to 12 and a pharmaceutically acceptable carrier.

14. Use of the complex of any one of claims 1 to 12 or the composition of claim 13 in the manufacture of a medicament for treating pre-diabetes, multiple sclerosis, allergic asthma, primary biliary cirrhosis, cirrhosis, Neuromyelitis optica spectrum disorder (Devic's disease, NMO), autoimmune encephalitis, autoantibody-mediated neurological syndromes, a Stiff

Man syndrome, paraneoplastic disease, other diseases of the central and peripheral nervous systems, Pemphigus vulgaris, inflammatory bowel disease, Crohn's disease, Ulcerative Colitis, arthritis, Rheumatoid Arthritis, systemic lupus erythematosus (SLE), Celiac Disease, psoriasis, Alopecia Areata, Acquired Thrombocytopenic Purpura, autoimmune cardiomyopathy, idiopathic dilated cardiomyopathy (IDCM), Myasthenia Gravis, Uveitis, Ankylosing Spondylitis, Grave's Disease, Hashimoto's thyroiditis, Immune Mediated Myopathies, anti-phospholipid syndrome (ANCA+), atherosclerosis, scleroderma, autoimmune hepatitis, dermatomyositis, chronic obstructive pulmonary disease, a spinal cord injury, traumatic injury, tobacco-induced lung destruction, Chronic Obstructive Pulmonary Disease (COPD), lung emphysema, sclerosing cholangitis, peripheral neuropathy, narcolepsy, Goodpasture Syndrome, Kawasaki's Disease, autoimmune uveitis, colitis, emphysema, pemphigus, pemphigus folliaceus, Sjogren's Syndrome, ANCA-associated vasculitis, primary sclerosing cholangitis-relevant antigen, adipose tissue inflammation/diabetes type II, or obesity associated adipose tissue inflammation/insulin resistance.

15. A complex comprising a nanoparticle core coupled to a plurality of type I diabetes-relevant antigen-MHC class II (pMHCII) complexes, wherein the nanoparticle core comprises a metal or metal oxide and has a diameter from about 1 nm to about 100 nm; wherein the type I diabetes-relevant pMHCII density per nanoparticle is from about 0.4 pMHC/100 nm^2 to about 15 pMHC/100 nm^2 of the surface area of the nanoparticle.

16. The complex of claim 15, wherein the MHCII molecule of the plurality of pMHCII complexes comprises HLA DR, HLA DQ, HLA DP, or a fragment thereof.

17. The complex of claim 16, wherein the MHCII molecule of the plurality of pMHCII complexes comprises HLA-DRB1/DRA, HLA-DRB3/DRA, HLA-DRB4/DRA, HLA-DRB5/DRA, HLA-DQA1/HLA-DQB1, HLA-DPB1/HLA-DPA1, or a fragment thereof.

18. The complex of any one of claims 15 to 17, the complex further comprises an outer layer.

19. The complex of any one of claims 15 to 18, wherein the valency of the plurality of pMHCII complexes per nanoparticle core is from about 10:1 to about 100:1.

20. The complex of any one of claims 15 to 19, wherein the nanoparticle core comprises a diameter from about 5 nm to about 50 nm.

21. The complex of any one of claims 15 to 20, wherein the nanoparticle core comprises a diameter from about 5 nm to about 25 nm.

22. The complex of any one of claims 15 to 21, wherein the type I diabetes relevant antigen is selected from the group comprising: one or more of preproinsulin (PPI), islet-specific glucose-6-phosphatase (IGRP), glutamate decarboxylase (GAD), islet cell autoantigen-2 (ICA2), insulin, and proinsulin, or a fragment or an equivalent of each thereof.

23. The complex of any one of claims 15 to 21, wherein the type I diabetes relevant antigen-pMHCII complexes are selected from the group comprising: $PPI_{76\text{-}90(K88S)}$-HLA-DRB1*0401/DRA, $IGRP_{13\text{-}25}$-HLA-DRB1*0301/DRA, $GAD_{555\text{-}567}$-HLA-DRB1*0401/DRA, $GAD_{555\text{-}567(557I)}$-HLA-DRB1*0401/DRA, $IGRP_{23\text{-}35}$-HLADRB1*0401/DRA, B_{24}-C_{36}-HLA-DRB1*0301/DRA, or PPI76-90-HLA-DRB1*0401/DRA.

24. The complex according to claim 23, wherein the type I diabetes relevant antigen-pMHCII complexes comprise $PPI_{76\text{-}90(K88S)}$-HLA-DRB1*0401/DRA or $IGRP_{13\text{-}25}$-HLA-DRB1*0301/DRA.

25. The complex of any one of claims 15 to 23, wherein the plurality of pMHC complexes are covalently coupled to the nanoparticle core by a linker.

26. The complex of claim 25, wherein the linker is less than 5 kD in size.

27. The complex of claim 25, wherein the linker comprises polyethylene glycol.

28. The complex of claim 25, wherein the linker is maleimide functionalized.

29. A method for differentiating an activated T cell or a memory T cell into a IL-10 producing T_R1 cell, the method comprising contacting the activated T cell or memory T cell with an effective amount of the complex of any one of claims 15 to 28.

30. A composition comprising a plurality of complexes of any of claims 15 to 29 and a pharmaceutically acceptable carrier.

31. Use of the complex of any one of claims 15 to 28 or the composition of claim 30 for the manufacture of a medicament for treating Type 1 diabetes.