

WHAT IS CLAIMED IS:

1. An isolated antibody comprising a heavy chain (HC) immunoglobulin variable domain and a light chain (LC) immunoglobulin variable domain sequence, wherein the HC and LC immunoglobulin variable domain sequences form an antigen binding site that binds to human FcRn; and, wherein the HC comprises:

a HC CDR1 comprising an amino acid sequence RSWMN (SEQ ID NO: 11) or DYAMH (SEQ ID NO: 17),

a HC CDR2 comprising an amino acid sequence RIHPGDGDTNYNGKFKG (SEQ ID NO: 12) or VITNYYGDASYNQKFKG (SEQ ID NO: 18), and

a HC CDR3 comprising an amino acid sequence EGSPYFDY (SEQ ID NO: 13), or GGYDGYVDFDY (SEQ ID NO: 19); and

the LC comprises:

a LC CDR1 comprising an amino acid sequence SASSSISSNYLH (SEQ ID NO: 8) or KASQDINNYIA (SEQ ID NO: 14),

a LC CDR2 comprising an amino acid sequence RTSNLAS (SEQ ID NO: 9) or YTSTLQP (SEQ ID NO: 15), and

a LC CDR3 comprising an amino acid sequence QQGSNIPLT (SEQ ID NO: 10) or LQYDNLLRT (SEQ ID NO: 16).

2. The isolated antibody of claim 1, wherein the HD comprises:

a HC CDR1 comprising the amino acid sequence RSWMN (SEQ ID NO: 11), a HC CDR2 comprising the amino acid sequence RIHPGDGDTNYNGKFKG (SEQ ID NO: 12), and a HC CDR3 comprising the amino acid sequence EGSPYFDY (SEQ ID NO: 13) and

the LC comprises:

a LC CDR1 comprising the amino acid sequence SASSSISSNYLH (SEQ ID NO: 8),

a LC CDR2 comprising the amino acid sequence RTSNLAS (SEQ ID NO: 9), and

a LC CDR3 comprising the amino acid sequence QQGSNIPLT (SEQ ID NO: 10).

3. The isolated antibody of claim 1, wherein the HC comprises:
 - a HC CDR1 comprising the amino acid sequence DYAMH (SEQ ID NO: 17), a HC CDR2 comprising the amino acid sequence VITNYYGDASYNQKFKG (SEQ ID NO: 18), and a HC CDR3 comprising the amino acid sequence GGYDGYVDFDY (SEQ ID NO: 19) and
 - the LC comprises:
 - a LC CDR1 comprising the amino acid sequence KASQDINNYIA (SEQ ID NO: 14),
 - a LC CDR2 comprising the amino acid sequence YTSTLQP (SEQ ID NO: 15), and
 - a LC CDR3 comprising the amino acid sequence LQYDNLLRT (SEQ ID NO: 16).
4. The isolated antibody of claim 1, wherein the LC immunoglobulin variable domain sequence of the isolated antibody comprises an amino acid sequence of SEQ ID NO: 20 or SEQ ID NO: 22, and the HC immunoglobulin variable domain sequence of the isolated antibody comprises an amino acid sequence of SEQ ID NO: 21 or SEQ ID NO: 23.
5. An isolated monoclonal antibody wherein the antibody binds to an FcRn epitope comprising an amino acid sequence selected from the group consisting of SCPHRLREHLERGRGNLEWK (SEQ ID NO: 24), ERGRGNLEWKEPPSMRLKAR (SEQ ID NO: 25), CSAFSFYPPQLRFLRNGL (SEQ ID NO: 26), and APGTPAFWVSGWLGPQQYLS (SEQ ID NO: 27).
6. The isolated antibody of any one of claims 1-5, for use as a medicament for modulating an FcRn activity in a human subject.
7. The antibody of any one of claims 1-6 for use in treating an autoimmune disorder and/or modulating symptoms of an autoimmune disorder.
8. The antibody of claim 7, wherein the autoimmune disorder is a disorder selected from the group consisting of rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), Myasthenia Gravis (MG), Graves Disease, Idiopathic Thrombocytopenia Purpura (ITP), Guillain-Barre Syndrome, autoimmune myocarditis, Membrane Glomerulonephritis, diabetes mellitus, Type I or Type II diabetes, multiple

sclerosis, Reynaud's syndrome, autoimmune thyroiditis, gastritis, Celiac Disease, Vitiligo, Hepatitis, primary biliary cirrhosis, inflammatory bowel disease, spondyloarthropathies, experimental autoimmune encephalomyelitis, immune neutropenia, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines, T-lymphocytes typically found in tuberculosis, sarcoidosis, and polymyositis, polyarteritis, cutaneous vasculitis, pemphigus, pemphigoid, Goodpasture's syndrome, Kawasaki's disease, systemic sclerosis, anti-phospholipid syndrome, and Sjogren's syndrome.

9. The antibody of any one of claims 1 to 5, for use as a medicament for modulating the half-life/levels of circulating IgG in a subject.

10. The antibody of any one of claims 1-5 for use as a medicament for reducing the concentration of undesired antibodies in an individual.

11. The antibody of claim 10, wherein the undesired antibody is natalizumab.

12. The antibody of claims 1-5 for use as a medicament for reducing the binding of IgG to FcRn in an individual.

13. A pharmaceutical composition comprising the antibody of claim 13-17 and a pharmaceutically acceptable carrier.

14. A method of detecting an FcRn in a sample, the method comprising contacting the sample with the antibody of claim 1-5; and detecting an interaction between the antibody and the FcRn if present.

15. Use of the antibody of claim 1-5 in the manufacture of a medicament for use in treating an autoimmune disorder and/or modulating symptoms of an autoimmune disorder.

16. The use of claim 15, wherein the autoimmune disorder is a disorder selected from the group consisting of rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), Myasthenia Gravis (MG), Graves Disease, Idiopathic Thrombocytopenia Purpura (ITP), Guillain-Barre Syndrome, autoimmune myocarditis, Membrane Glomerulonephritis, diabetes mellitus, Type I or Type II diabetes, multiple sclerosis, Reynaud's syndrome, autoimmune

thyroiditis, gastritis, Celiac Disease, Vitiligo, Hepatitis, primary biliary cirrhosis, inflammatory bowel disease, spondyloarthropathies, experimental autoimmune encephalomyelitis, immune neutropenia, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines, T-lymphocytes typically found in tuberculosis, sarcoidosis, and polymyositis, polyarteritis, cutaneous vasculitis, pemphigus, pemphigoid, Goodpasture's syndrome, Kawasaki's disease, systemic sclerosis, anti-phospholipid syndrome, and Sjogren's syndrome.

ANTIBODIES AGAINST FcRn AND USE THEREOF

Abstract

This disclosure provides, inter alia, proteins that bind to FcRn, *e.g.* immunoglobulins that
5 inhibit FcRn with high affinity and selectivity. The FcRn-binding proteins can be used to treat a
variety of disorders including autoimmune disorders.

Figure 36

WHAT IS CLAIMED IS:

1. An isolated antibody comprising a heavy chain (HC) immunoglobulin variable domain sequence and a light chain (LC) immunoglobulin variable domain sequence, wherein the heavy chain and light chain immunoglobulin variable domain sequences form an antigen binding site that binds to human FcRn; and wherein the antibody includes one or more of the following characteristics:
 - (a) a human CDR or human framework region;
 - (b) the LC immunoglobulin variable domain sequence comprises one or more CDRs that are at least 85% identical to a CDR of a LC variable domain of M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 or DX2500;
 - (c) the HC immunoglobulin variable domain sequence comprises one or more CDRs that are at least 85% identical to a CDR of a HC variable domain of M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 or DX2500;
 - (d) the LC immunoglobulin variable domain sequence is at least 85% identical to a LC variable domain of M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 or DX2500;
 - (e) the HC immunoglobulin variable domain sequence is at least 85% identical to a HC variable domain of M0171-A03, M0171-A01, M0159-A07, M0161-B04 M0090-F11 or DX2500; and
 - (f) the antibody binds an epitope that overlaps with an epitope bound by M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 or DX2500.
2. An isolated antibody that is at least 85% identical to an antibody selected from the group consisting of M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 and DX2500.
3. An isolated antibody that is at least 85% identical to M0161-B04.
4. An isolated antibody that is at least 85% identical to M0171-A03.

5. An isolated antibody that is at least 85% identical to M0171-A01.
6. An isolated antibody that is at least 85% identical to M0159-A07.
7. An isolated antibody that is at least 85% identical to M0090-F11.
8. An isolated antibody that is at least 85% identical to DX-2500.
9. The antibody of claim 1, wherein the antibody binds to an FcRn epitope bound by M0171-A03, M0171-A01, M0159-A07, M0161-B04, M0090-F11 or DX2500.
10. The antibody of claim 1, wherein the antibody competes with M0171-A03, M0171 A01, M0159-A07, M0161-B04, M0090-F11 or DX2500 for binding to FcRn.
11. An isolated antibody, or a fragment thereof, which binds to human FcRn, wherein the antibody is generated against the heavy chain of human FcRn or a fragment thereof, wherein the antibody functions as a non-competitive inhibitor of IgG binding to human FcRn, and wherein the antibody does not bind β 2-microglobulin.
12. An isolated antibody, or fragment thereof, that binds to human FcRn, wherein the antibody is generated against the heavy chain of human FcRn or a fragment thereof, wherein the antibody does not bind β 2-microglobulin when it is not complexed with FcRn, and wherein the antibody is not produced from a FcRn $-/-$ knockout mouse.
13. The antibody of claim 12, wherein the antibody is selected from the group consisting of 3B3.11, 31.1, 4B4.12, and 17D3.
14. The antibody of any one of claims 1-13, wherein the antibody binds human FcRn at about pH range 5-7.4 with a dissociation constant (K_D) of less than 100 nM.

15. The antibody of any one of claims 1-13, wherein the antigen binding site specifically binds to human FcRn.
16. The antibody of any one of claims 1-13, wherein the antibody binds a stable FcRn expressing cell line.
17. The antibody of any one of claims 1-13, wherein the antibody modulates FcRn binding to an antibody/immunoglobulin constant region.
18. The antibody of any one of claims 1-13, wherein the antibody binds to the alpha subunit of FcRn.
19. The antibody of any one of claims 1-13, wherein the antibody binds the $\alpha 1$, $\alpha 2$, or $\alpha 3$ domain of the FcRn alpha chain.
20. The antibody of any one of claims 1-13, wherein the antibody does not bind a beta subunit of FcRn, *i.e.*, the protein only binds an alpha subunit.
21. The antibody of any one of claims 1-13, wherein the antibody binds to a beta subunit of FcRn, wherein the beta subunit is associated with an alpha subunit.
22. The antibody of any one of claims 1-13, wherein the alpha and beta subunit are correctly assembled into FcRn.
23. The antibody of any one of claims 1-13, wherein the antibody binds an FcRn that contains both an alpha subunit and a beta subunit and is correctly assembled.
24. The antibody of any one of claims 1-13, wherein the antibody inhibits the binding of IgG-Fc with an IC_{50} of less than about 800 nM, less than about 600 nM, less than about 300

nM, less than about 100 nM, less than about 50, nM, less than about 25 nM, less than about 10 nM, or less than about 5 nM at about pH 6.

25. The antibody of any one of claims 1-13, wherein the antibody is soluble Fab.
26. The antibody of any one of claims 1-13, wherein the antibody binds to FcRn through its antigen binding domain and also through its Fc region.
27. The antibody of any one of claims 1-13, wherein the binding of the antibody to FcRn is substantially pH independent in the range of 2-10.
28. The antibody of any one of claims 1-13, wherein the binding of the antibody to FcRn is substantially pH independent in the range of 6-8.
29. The antibody of any one of claims 1-13, wherein the antibody has a k_{off} of less than 0.01, 0.001, 0.0001, 0.00001 s^{-1} at pH 7.5.
30. The antibody of any one of claims 1-13, wherein the binding of the antibody to FcRn is substantially pH dependent.
31. The antibody of any one of claims 1-13, wherein the antibody preferentially binds human FcRn as compared to rat FcRn in a pH-dependent or pH-independent manner.
32. The antibody of any one of claims 1-13, wherein the antibody binds FcRn in endosomes or under endosomal conditions.
33. The antibody of any one of claims 1-13, wherein the antibody does not release FcRn at pH 7.5.

34. The antibody of any one of claims 1-13, wherein the antibody causes an amelioration of symptoms associated with an autoimmune disorder when administered to a subject.
35. The antibody of any one of claims 1-13, wherein the HC and LC variable domain sequences are components of the same polypeptide chain.
36. The antibody of any one of claims 1-13, wherein the HC and LC variable domain sequences are components of different polypeptide chains.
37. The antibody of any one of claims 1-13, wherein the antibody is a full-length antibody.
38. The antibody of any one of claims 1-13, wherein the antibody is a human or humanized antibody or is non-immunogenic in a human.
39. The antibody of any one of claims 1-13, wherein the antibody comprises a human antibody framework region.
40. The antibody of any one of claims 1-13, wherein the antibody comprises an Fc domain.
41. The antibody of any one of claims 1-13, wherein the antibody is a murine antibody.
42. The antibody of any one of claims 1-13, wherein the antibody is a monoclonal antibody.
43. The antibody of any one of claims 1-13, wherein the antibody is chimeric or humanized.

44. The antibody of any one of claims 1-13, wherein the antibody is selected from the group consisting of Fab, F(ab)'₂, Fv and ScFv.

45. The antibody of any one of claims 1-13, wherein the antibody binding to FcRn is independent of the pH over a pH range of 6.0 to 8.0.

46. An isolated nucleic acid comprising a sequence that encodes a polypeptide that includes a sequence at least 80% identical to the sequence of a variable domain of M0171-A03, M0171-A01, M0159-A07 or M0161-B04.

47. Use of the antibody of any one of claims 1-45 in the manufacture of a medicament for detecting FcRn in a subject, the use comprising:
administration of the medicament, that further comprises a detectable label, to a subject; and
detecting the label in the subject, wherein the detecting comprises imaging the subject.

48. A method of modulating an FcRn activity, the method comprising:
contacting an FcRn with the antibody of any one of claims 1-45, thereby modulating the activity of the FcRn, wherein the antibody prevents binding of the FcRn to an endogenous Ig.

49. A method of modulating an FcRn activity, the method comprising:
contacting an FcRn with the antibody of any one of claims 1-45, thereby modulating the activity of the FcRn, wherein the antibody prevents binding of the FcRn to a therapeutic antibody.

50. The method of claim 48 or 49, wherein the FcRn is in an epithelial cell endosome.

51. The method of claim 48 or 49, wherein the FcRn is in an endothelial cell endosome.

52. The method of claim 48 or 49, wherein the FcRn is on the cell surface

53. Use of the antibody of any one of claims 1-45 in the manufacture of a medicament for treating pemphigus and/or modulating symptoms of pemphigus, , wherein the pemphigus is pemphigus vulgaris, pemphigus foliaceus or paraneoplastic pemphigus.

54. Use of the antibody of any one of claims 1-45 in the manufacture of a medicament for treating an autoimmune disorder and/or modulating symptoms of an autoimmune disorder, wherein the antibody decreases the half-life of endogenous IgG.

55. A method of modulating the half-life/levels of circulating IgG, the method comprising:
identifying a subject in need of modulated circulating IgG half life/levels; and
administration of the antibody of any one of claims 1-45 to the subject in an amount effective to modulate the half life/levels of circulating IgG in the subject, wherein the method reduces circulating IgG half life/levels.

56. The method of claim 55, wherein the antibody is administered to decrease the half life/levels of circulating IgG and in combination with an anti-autoimmune disorder agent or therapy that is not the antibody of any one of claims 1-45.

57. Use of the antibody of any one of claims 1-45 in the manufacture of a medicament for treating or preventing an autoimmune disorder, the use comprising:
administration of the medicament to a subject having the disorder or at risk of developing the disorder.

58. The use of claim 57, wherein the autoimmune disorder is characterized by unwanted circulating IgG.

59. The use of claim 57, wherein the antibody decreases the half-life of endogenous IgG

60. The use of claim 57, wherein the autoimmune disorder is a disorder selected from rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), Myasthenia Gravis (MG), Graves Disease, Idiopathic Thrombocytopenia Purpura (ITP), Guillain-Barre Syndrome, autoimmune myocarditis, Membrane Glomerulonephritis, diabetes mellitus, Type I or Type II diabetes, multiple sclerosis, Reynaud's syndrome, autoimmune thyroiditis, gastritis, Celiac Disease, Vitiligo, Hepatitis, primary biliary cirrhosis, inflammatory bowel disease, spondyloarthropathies, experimental autoimmune encephalomyelitis, immune neutropenia, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines, T-lymphocytes typically found in tuberculosis, sarcoidosis, and polymyositis, polyarteritis, cutaneous vasculitis, pemphigus, pemphigoid, Goodpasture's syndrome, Kawasaki's disease, systemic sclerosis, anti-phospholipid syndrome, and Sjogren's syndrome.

61. The use of claim 60, wherein the pemphigus is pemphigus vulgaris, pemphigus foliaceus or paraneoplastic pemphigus.

62. Use of the antibody of any one of claims 1-45 in the manufacture of a medicament for treating or preventing an autoimmune disorder, the use comprising:
administration of the medicament, in combination with a second therapy for treating or preventing the disorder to a subject having the disorder or at risk of developing the disorder.

63. The use of claim 62, wherein the second therapy comprises intravenous Ig therapy; nonsteroidal anti-inflammatory drugs (NSAID); corticosteroids; cyclosporins, rapamycins, ascomycins, or their immunosuppressive analogs, *e.g.*, cyclosporin A, cyclosporin G, FK-506, rapamycin, 40-O-(2-hydroxy)ethyl-rapamycin; cyclophosphamide; azathioprene; methotrexate; brequinar; FTY 720; leflunomide; mnizoribine; mycophenolic acid; mycophenolate mofetil; 15-deoxyspergualine; immunosuppressive monoclonal antibodies, *e.g.*,

monoclonal antibodies to leukocyte receptors, *e.g.*, MHC, CD2, CD3, CD4, CD7, CD25, CD28, B7, CD45, or CD58 or their ligands; other immunomodulatory compounds, *e.g.*, CTLA4Ig; or other adhesion molecule inhibitors, *e.g.*, mAbs or low molecular weight inhibitors including selectin antagonists and VLA-4 antagonists.

64. Use of an antibody or a fragment thereof according to any one of claims 1-45 in the manufacture of a medicament for reducing the concentration of undesired antibodies in an individual, wherein the medicament is to be administered in a pharmaceutically acceptable carrier.

65. Use of an antibody or a fragment thereof according to any one of claims 1-45 in the manufacture of a medicament for reducing the concentration of undesired antibodies in an individual, wherein the medicament is to be administered with an adjuvant.

66. Use of an antibody or a fragment thereof according to any one of claims 1-45 in the manufacture of a medicament for reducing the concentration of undesired antibodies in an individual, wherein the undesired antibody is non-self Human Leukocyte Antigen.

67. The use of claim 66, wherein the administered antibody or fragment thereof is to be administered in connection with organ transplant.

68. Use of an antibody or a fragment thereof according to any one of claims 1-45 in the manufacture of a medicament for reducing the binding of IgG to FcRn in an individual comprising the steps of

providing an antibody or a fragment thereof which binds to human FcRn, is generated against the heavy chain of human FcRn or a fragment thereof, is a non-competitive inhibitor of IgG binding to human FcRn and does not bind β 2-microglobulin; and

administration of the medicament to an individual in an amount sufficient to reduce the binding of IgG to FcRn in the individual.

69. The use of claim 68, wherein the individual has an autoimmune or alloimmune disease.

70. The use of claim 68, wherein the individual is an organ transplant recipient.

71. The use of claim 68, wherein the individual has been administered a therapeutic antibody.

72. The use of claim 68, wherein the autoimmune disease is immune thrombocytopenia.

73. The use of claim 68, wherein the autoimmune disease is immune pemphigus.

74. The use of claim 68, wherein the antibody is to be administered at a dosage of 1 mg/kg to 2 g/kg.

75. The use of claim 68, wherein the antibody is to be administered at a dosage of 1 mg/kg to 200 mg/kg.

76. Use of an antibody or a fragment thereof which binds to human FcRn for the manufacture of a medicament for suppressing the level of an IgG antibody in an individual comprising the steps of

providing an antibody or a fragment thereof which binds to human FcRn, is generated against the heavy chain of human FcRn or a fragment thereof, is a non-competitive inhibitor of IgG binding to human FcRn and does not bind β 2-microglobulin; and

administration of the medicament to an individual in an amount sufficient to suppress the level of an IgG antibody in an individual.

77. The use of claim 76, wherein the IgG antibody is a therapeutic IgG antibody.

78. The use of claim 76, wherein the therapeutic IgG antibody is natalizumab.
79. The use of claim 76, wherein the IgG antibody is non-self Human Leukocyte Antigen.
80. The use of claim 76, wherein the method further comprises a plasma exchange step.