IMMUNOTHERAPY REGIMES DEPENDENT ON APOE STATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Provisional US Application Nos. 60/999,423 and 61/083,827, filed October 17, 2007 and July 25, 2008, respectively, are incorporated by reference in their entirety for all purposes.

BACKGROUND OF THE INVENTION

I. General

[0002] Alzheimer's disease (AD) is a progressive disease resulting in senile dementia. *See* generally Selkoe, *TINS* 16:403 (1993); Hardy *et al.*, WO 92/13069; Selkoe, *J. Neuropathol. Exp. Neurol.* 53:438 (1994); Duff *et al.*, *Nature* 373:476 (1995); Games *et al.*, *Nature* 373:523 (1995). Broadly speaking, the disease falls into two categories: late onset, which occurs in old age (65 + years) and early onset, which develops well before the senile period, *i.e.*, between 35 and 60 years. In both types of disease, the pathology is the same but the abnormalities tend to be more severe and widespread in cases beginning at an earlier age. The disease is characterized by at least two types of lesions in the brain, neurofibrillary tangles and senile plaques. Neurofibrillary tangles are intracellular deposits of microtubule associated tau protein consisting of two filaments twisted about each other in pairs. Senile plaques (*i.e.*, amyloid plaques) are areas of disorganized neuropile up to 150 μm across with extracellular amyloid deposits at the center which are visible by microscopic analysis of sections of brain tissue. The accumulation of amyloid plaques within the brain is also associated with Down's syndrome and other cognitive disorders.

[0003] The principal constituent of the plaques is a peptide termed Aβ or β-amyloid peptide. Aβ peptide is a 4-kDa internal fragment of 39-43 amino acids of a larger transmembrane glycoprotein named amyloid precursor protein (APP). As a result of proteolytic processing of APP by different secretase enzymes, Aβ is primarily found in both a short form, 40 amino acids in length, and a long form, ranging from 42-43 amino acids in length. Part of the hydrophobic transmembrane domain of APP is found at the carboxy end of Aβ, and may account for the ability of Aβ to aggregate into plaques, particularly in the case of the long form. Accumulation of amyloid plaques in the brain eventually leads to neuronal cell death. The physical symptoms associated with this type of neural deterioration characterize Alzheimer's disease.

[0004] Several mutations within the APP protein have been correlated with the presence of Alzheimer's disease. *See, e.g.*, Goate *et al.*, *Nature* 349:704 (1991) (valine^{717} to isoleucine); Chartier Harlan *et al.*, *Nature* 353:844 (1991)) (valine^{717} to glycine); Murrell *et al.*, *Science* 254:97 (1991) (valine^{717} to phenylalanine); Mullan *et al.*, *Nature Genet.* 1:345 (1992) (a double mutation changing lysine^{595}-methionine^{596} to asparagine^{595}-leucine^{596}). Such mutations are thought to cause Alzheimer's disease by increased or altered processing of APP to Aβ, particularly processing of APP to increased amounts of the long form of Aβ (*i.e.*, Aβ1-42 and Aβ1-43). Mutations in other genes, such as the presenilin genes, PS1 and PS2, are thought indirectly to affect processing of APP to generate increased amounts of long form Aβ (*see* Hardy, *TINS* 20: 154 (1997)).

[0005] Apolipoprotein E (ApoE) encodes a cholesterol-processing protein. The gene, which maps to 19q13.2, has three allelic variants: ApoE4, ApoE3, and ApoE2. The frequency of the apoE4 version of the gene in the general population varies, but is always less than 30% and frequently 8%–15%. ApoE3 is the most common form and ApoE2 is the least common. Persons with one E4 allele usually have about a two to three fold increased risk of developing Alzheimer's disease. Persons with two E4 alleles (usually around 1% of the population) have about a nine–fold increase in risk. Nonetheless, even persons with two E4 alleles do not always get Alzheimer's disease. At least one E4 allele is found in about 40% of patients with late–onset Alzheimer's disease. Genetic screening for E4 has not been routinely performed, because it has not been known how to use this information for a therapeutic regime.

SUMMARY OF THE CLAIMED INVENTION

[0006] The invention provides a method of treating Alzheimer's disease, comprising administering to a patient having zero ApoE4 alleles ("ApoE4 non-carrier patient") and Alzheimer's disease, an effective regime of an antibody that specifically binds to an N-terminal epitope of Aβ. Optionally, the antibody specifically binds to an epitope within residues 1-7 of Aβ, or an epitope within residues 1-5 of Aβ, or an epitope within residues 3-7 of Aβ. Optionally, the dosage of the antibody within a range of about 0.15 mg/kg to about 2 mg/kg is administered by intravenous infusion. Optionally, the dosage is administered every 4 to 16 weeks. Optionally, the dosage is administered every 10 to 14 weeks. Optionally, the dosage is administered every 13 weeks. Optionally, the dosage is about 0.5 mg/kg to about 1 mg/kg. Optionally, the dosage is about 0.5 mg/kg to 2 mg/kg. Optionally, the dosage is

about 2 mg/kg. Optionally, the antibody is bapineuzumab. Optionally, the method also involves monitoring for vasogenic edema, and optionally administering a corticosteroid to the patient to treat vasogenic edema detected by the monitoring.

[0007] The invention also provides a method of reducing cognitive decline in a patient having zero ApoE4 alleles ("ApoE4 non-carrier patient"), comprising administering to the patient an antibody that specifically binds to an N-terminal epitope of Aβ in a regime effective to reduce the cognitive decline of the patient relative to a control patient to whom the antibody is not administered; wherein: the ApoE4 non-carrier patient and control patient have been diagnosed with mild to moderate Alzheimer's disease; and the cognitive decline is measured by ADAS-COG, NTB, MMSE or CDR-SB. Optionally, the antibody is administered by intravenous infusion at a dosage within a range of about 0.15 mg/kg to about 2 mg/kg. Optionally, the antibody is bapineuzumab. Optionally, the dosage is about 0.5 mg/kg and the cognitive decline is measured by ADAS-COG. Optionally, the dosage is about 2 mg/kg and the cognitive decline is measured by ADAS-COG. Optionally, the cognitive decline is measured by NTB. Optionally, the dosage is 0.5 mg/kg. Optionally, the dosage is about 0.5 mg/kg and the cognitive decline is measured by CDR. Optionally, the dosage is about 0.5 mg/kg and the cognitive decline is measured by MMSE. Optionally, the dosage is about 2 mg/kg and the cognitive decline is measured by MMSE.

[0008] The invention also provides a method of reducing brain volume decline in a patient having zero ApoE4 alleles ("ApoE4 non-carrier patient"), comprising administering to the ApoE4 non-carrier patient an antibody that specifically binds to an N-terminal epitope of Aβ in a regime effective to reduce the brain volume decline of the ApoE4 non-carrier patient relative to a control patient to whom the antibody is not administered; wherein the ApoE4 non-carrier patient and control patient have been diagnosed with mild to moderate Alzheimer's disease. Optionally, the antibody is administered by intravenous infusion at a dosage within a range of about 0.15 mg/kg to about 2 mg/kg. Optionally, the antibody is bapineuzumab. Optionally, the dosage is about 0.5 mg/kg. Optionally, the dosage is about 2 mg/kg. Optionally, the brain volume decline is measured by MRI.

[0009] The invention also provides a method of treating Alzheimer's disease, comprising administering to an ApoE4 non-carrier patient an antibody that specifically recognizes the N-terminal region of Aβ in a regime effective to maintain a mean serum concentration of the antibody in the range of about 0.1 μg/ml to about 60 μg/ml. Optionally, the range is about

0.4 μg/ml to about 20 μg/ml. Optionally, the range is about 1 μg/ml to about 5 μg/ml. Optionally, the maximum serum concentration of the antibody in the patient less than about 28 μg antibody/ml serum. Optionally, the maximum serum concentration is within a range of about 4-18 μg antibody/ml serum. Optionally, the antibody is bapineuzumab.

[0010] The invention also provides a method of treating Alzheimer's disease, comprising administering to an ApoE4 non-carrier patient an antibody that specifically recognizes the N-terminal region of Aβ in a regime effective to achieve a mean plasma Aβ concentration of at least 450 pg/ml. Optionally, the mean plasma Aβ concentration is in the range of about 600 pg/ml to about 3000 pg/ml. Optionally, the mean plasma Aβ concentration is in the range of about 700 pg/ml to about 2000 pg/ml. Optionally, the mean plasma Aβ concentration is in the range of about 700 pg/ml to about 2000 pg/ml. Optionally, the mean plasma Aβ concentration is in the range of about 800 pg/ml to about 1000 pg/ml.

[0011] The invention also provides a method of treating Alzheimer's disease, comprising subcutaneously administering to a patient having the disease and one or two copies of an ApoE4 allele an effective regime of an antibody that binds to an N-terminal epitope of Aβ. Optionally, the method further comprises monitoring for vasogenic edema. Optionally, the antibody is administered at a dose of 0.01-0.6 mg/kg and a frequency of between weekly and monthly. Optionally, the antibody is administered at a dose of 0.05-0.5 mg/kg. Optionally, the antibody is administered at a dose of 0.05-0.25 mg/kg. Optionally, the antibody is administered at a dose of 0.015-0.2 mg/kg weekly to biweekly. Optionally, the antibody is administered at a dose of 0.05-0.15 mg/kg weekly to biweekly. Optionally, the antibody is administered at a dose of 0.05-0.07 mg/kg weekly. Optionally, the antibody is administered at a dose of 0.06 mg/kg weekly. Optionally, the antibody is administered at a dose of 0.1 to 0.15 mg/kg biweekly. Optionally, the antibody is administered at a dose of 0.1 to 0.3 mg/kg monthly. Optionally, the antibody is administered at a dose of 0.2 mg/kg monthly. Optionally, the antibody is administered at a dose of 1-40 mg and a frequency of between weekly and monthly. Optionally, the antibody is administered at a dose of 5-25 mg. Optionally, the antibody is administered at a dose of 2.5-15 mg. Optionally, the antibody is administered at a dose of 1-12 mg weekly to biweekly. Optionally, the antibody is administered at a dose of 2.5-10 mg weekly to biweekly. Optionally, the antibody is administered at a dose of 2.5-5 mg weekly. Optionally, the antibody is administered at a dose

of 4-5 mg weekly. Optionally, the antibody is administered at a dose of 7-10 mg biweekly. Optionally, the method further comprises monitoring for vasogenic edema.

[0012] The invention further comprises a method of treating Alzheimer's disease, comprising administering to a patient having the disease and one or two ApoE4 alleles an effective regime of an antibody that binds to an N-terminal epitope of Aβ; administering a corticosteroid to the patient to treat vasogenic edema arising from the administration of the antibody. Optionally, the method further comprises monitoring the patient for vasogenic edema. Optionally, the dose or frequency of administration of the antibody is reduced or eliminated during the vasogenic edema relative to the dose or frequency before the vasogenic edema. Optionally, the dose or frequency of administration of the antibody is increased after resolution of the vasogenic edema relative to the dose or frequency either before or during the vasogenic edema.

[0013] The invention further comprises a method of treating or effecting prophylaxis in a population of patients of an amyloidogenic disease characterized by amyloid deposits of Aβ in the brain, comprising: administering different regimes to different patients in the population depending on which allelic forms of ApoE are present in the patients; wherein at least one of the regimes comprises administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient. Optionally, the different regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient; and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits and/or the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum serum concentration of the agent or antibodies induced by the agent is reduced and/or the time of initiation of treatment relative to disease progression is earlier in (a) patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4 allele.

[0014] Optionally, a first regime comprises administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient and a second regime lacks an antibody to Aβ or an agent that induces an antibody to Aβ and the first regime is administered to patients having zero copies of an ApoE4 allele and the second regime is

administered to patients having one or two copies of an ApoE4 allele. Optionally, a first regime comprises administering a first antibody to Aβ and the second regime comprises administering a second antibody to Aβ and the second antibody has reduced binding to an Fcγ receptor or C1q relative to the first antibody, and the first antibody is administered to patients having zero copies of an ApoE4 allele and the second antibody is administered to patients having one or two copies of an ApoE4 allele. Optionally, the second antibody has one or more mutations in the constant region that reduce binding to the Fcγ receptor and/or C1q, the mutations not being present in the first antibody. Optionally, the one or more mutations is/are at position(s) in a heavy chain constant region selected from the group consisting of positions 234, 235, 236 and 237 (EU numbering). Optionally, the one or more mutations are mutations at positions 234, 235 and 237. Optionally, the one or more mutations are L234A, L235A and G237A. Optionally, the isotype of the constant region is human IgG1. Optionally, the isotype of the constant region is human IgG2 or IgG4. Optionally, the first antibody is bapineuzumab and the second antibody is an L234A, L235A, G237A variant of bapineuzumab. Optionally, a first regime comprises administering a first antibody to Aβ and a second regime comprises administering a second antibody to Aβ, the first antibody being of human IgG1 isotype and the second antibody of human IgG4 isotype, and the first antibody is administered to patients having zero copies of an ApoE4 allele and the second antibody is administered to patients having one or two copies of an ApoE4 allele.

[0015] In some methods, the disease is Alzheimer's disease. Some methods further comprise determining which alleles of ApoE are present in the patient.

[0016] Optionally, the different regimes differ in dose of the agent administered. Optionally, the different regimes differ in frequency of the agent administered. Optionally, the different regimes differ in the type of agent administered.

[0017] Optionally, the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits is reduced in (a) patients having two ApoE4 alleles relative to patients having one ApoE4 allele; and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4 allele. Optionally, the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits is reduced in patients having one or two ApoE4 alleles relative to patients

having zero ApoE4 alleles of an ApoE4 allele. Optionally, patients in the population having one or two ApoE4 alleles are administered a dose of 0.15-1 mg/kg, and patients in the population having zero ApoE4 alleles are administered a dose of 0.5-2 mg/kg of an antibody specifically binding within residues 1-11 of Aβ. Optionally, the patients in the population having one or two ApoE4 alleles are administered a lower dosage of agent than patients having zero ApoE4 alleles until vasogenic edema has appeared and resolved, and the same dosage of agent thereafter.

[0018] Optionally, the patients in the population having one or two ApoE4 alleles are administered a lower frequency of the agent than the patients having zero ApoE4 alleles until vasogenic edema has appeared and resolved, and the same dosage of agent thereafter. Optionally, the patients in the population having one or two ApoE4 alleles are administered an antibody with reduced capacity to induce a clearing response to amyloid deposits relative to bapineuzumab.

[0019] Optionally, the method further comprises monitoring at least some of the patients in the population for vasogenic edema. Optionally, the monitoring is performed by MRI. Optionally, patients in the population with zero ApoE4 alleles are not monitored by MRI. Optionally, the agent is an antibody binding to an epitope within residues 1-11 of Aβ. Optionally, the antibody has human IgG1 isotype. Optionally, the antibody is bapineuzumab. Optionally, the agent is an antibody having reduced capacity to induce a clearing response to amyloid deposits relative to bapineuzumab. Optionally, the antibody is an L234A, L235A, G237A variant of bapineuzumab.

[0020] Optionally, wherein patients with one or two ApoE4 alleles are administered 1-3 doses of humanized 266 antibody following by subsequent doses of bapineuzumab and patients with zero ApoE4 alleles are administered the same total number of doses but all with bapineuzumab. In some methods, the antibody is a humanized 266 antibody. Optionally, patients with one or two ApoE4 alleles are administered humanized 266 and patients with zero ApoE4 alleles are administered bapineuzumab.

[0021] The invention further provides a method of monitoring a population of patients undergoing treatment or prophylaxis for a disease characterized by amyloid deposits of Aβ in the brain with an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ, the method comprising: performing different monitoring regimes in different patients in the

population for vasogenic edema, wherein the frequency of monitoring is greater for (a) patients having two copies of ApoE4 relative to patients having zero copies of ApoE4 and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4 allele. Optionally, the disease is Alzheimer's disease. Optionally, the method further comprises determining which allelic forms of ApoE are present in each patient in the population. Optionally, the monitoring is by brain imaging. Optionally, the monitoring is by MRI. Optionally, patients having one ApoE4 allele are monitored more frequently than patients having zero ApoE4 alleles. Optionally, patients having two ApoE4 alleles are monitored more frequently than patients having one ApoE4 allele. Optionally, patients having one ApoE4 allele are monitored more frequently than patients having zero ApoE4 alleles. Optionally, patients having zero ApoE4 alleles are not monitored by MRI for vasogenic edema.

[0022] The invention further provides a method of treating or effecting prophylaxis of a patient for a disease characterized by amyloid deposits of Aβ in the brain, comprising administering to a patient with at least one ApoE4 allele an agent that is an antibody to an epitope within residue 1-11 of Aβ or an agent that induces such an antibody to Aβ, and monitoring the patient for vasogenic edema by MRI. Optionally, the agent is bapineuzumab. Optionally, the agent is an L234A, L235A, G237A variant of bapineuzumab.

[0023] The invention further provides a method of treating or effecting prophylaxis of a disease characterized by amyloid deposits of Aβ in the brain in a patient having at least one ApoE4 allele, comprising administering a first regime to the patient before vasogenic edema appears, and a second regime after vasogenic edema has resolved; wherein the first and second regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient; and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to clear amyloid deposits is reduced in the first regime relative to the second regime. Optionally, the disease is Alzheimer's disease. Optionally, the patient has one or two ApoE4 alleles. Optionally, the first and second regimes each comprises administering an antibody that specifically binds to an epitope within residues 1-11 of Aβ to the patient, and the antibody is administered at a dose of 0.15-1mg/kg before vasogenic edema appears and 0.5-2 mg/kg after vasogenic edema

has resolved. Optionally, the antibody is bapineuzumab. Optionally, the antibody is a L234A, L235A, G237A variant of bapineuzumab.

[0024] The invention further provides a method of treating or effecting prophylaxis of Alzheimer's disease in a patient, comprising administering to the patient an antibody that specifically binds to an epitope within residues 1-11 of Aβ to a patient having one or two ApoE4 alleles, wherein the antibody is administered in a regime in which 0.15-1 mg/kg of antibody is administered quarterly by intravenous administration, or at a dose frequency and route of administration that generates an equivalent average serum concentration or area under the curve. Optionally, the antibody is bapineuzumab. Optionally the dose is 0.5 mg/kg.

[0025] The invention further provides a method of treating or effecting prophylaxis of Alzheimer's disease in a patient, comprising administering to the patient an antibody that specifically binds to an epitope within residues 1-11 of Aβ to a patient having zero ApoE4 alleles, wherein the dose of the antibody is 0.5-2 mg/kg administered quarterly by intravenous administration, or a dose frequency and route of administration that generates an equivalent serum concentration or area under the curve. Optionally, the antibody is an L234A, L235A, G237A variant of bapineuzumab.

[0026] The invention further provides a method of treating or effecting prophylaxis of Alzheimer's disease in a population of patients, comprising administering an antibody that specifically binds to an epitope within residues 1-11 of Aβ to the patients, wherein the antibody is administered at a dose of 0.15-1mg/kg in patients of the population having one or two ApoE4 alleles and a dose of 0.5-2.5 mg/kg in patients of the population having zero ApoE4 alleles, and the mean dose is higher in the patients having zero ApoE4 alleles. Optionally, the antibody is bapineuzumab. Optionally, the antibody is an L234A, L235A, G237A variant of bapineuzumab. Optionally, the dose is 0.5 mg/kg in patients of the population having one or two ApoE4 alleles and 2 mg/kg in patients of the population having zero ApoE4 alleles.

[0027] The invention further provides a use of a measurement of ApoE4 copy number is selecting from different regimes for treatment or prophylaxis of a disease characterized by amyloid deposits in the brain in the patient wherein the different regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ

on administration to a patient, and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits and/or the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum serum concentration of the agent or antibodies induced by the agent is reduced and/or the time of initiation of treatment relative to disease progression is earlier in a regime administered to (a) patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4.

[0028] The invention further provides a method of selecting a regime for treatment or prophylaxis of a disease characterized by amyloid deposits in the brain of a patient, the method comprising determining the number of ApoE4 alleles present in a patient; selecting from different regimes based on the number of ApoE4 alleles present, wherein the different regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient, and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits and/or the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum serum concentration of the agent or antibodies induced by the agent is reduced and/or the time of initiation of treatment relative to disease progression is earlier in (a) patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4.

[0029] The invention further provides a use of a measurement of ApoE4 copy number in the manufacture of a medicament to treat Alzheimer's disease, wherein the medicament comprises an antibody to Aβ or an agent that induces an antibody to Aβ.

[0030] The invention further provides a use of at least one agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient in the manufacture of a medicament for the treatment or prophylaxis of a disease characterized by amyloid deposits in the brain of a patient by different regimes depending on the number of ApoE4 alleles in the patient, wherein the different regimes comprise administering an agent to a patient and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of

the agent to induce a clearing response to amyloid deposits and/or the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum serum concentration of the agent or antibodies induced by the agent is reduced and/or the time of initiation of treatment relative to disease progression is earlier in (a) patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4.

[0031] The invention further provides a method of treating or effecting prophylaxis in a population of patients of an amyloidogenic disease characterized by amyloid deposits of Aβ in the brain, comprising: administering different regimes to different patients in the population depending on which allelic forms of ApoE are present in the patients; wherein the different regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient; and the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum concentration of the agent or antibodies induced by the agent is reduced in patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4.

[0032] The invention further provides a method of treating or effecting prophylaxis in a population of patients of an amyloidogenic disease characterized by amyloid deposits of Aβ in the brain, comprising: determining the ApoE4 status of the patient; administering different regimes to different patients in the population depending on which allelic forms of ApoE are present in the patients; wherein the different regimes each comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient; and the dose of the agent and/or the frequency of administration of the agent and/or the capacity of the agent to induce a clearing response to amyloid deposits and/or the mean serum concentration of the agent or antibodies induced by the agent and/or the maximum serum concentration of the agent or antibodies induced by the agent is reduced and/or the time of initiation of treatment relative to disease progression is earlier in (a) patients having two copies of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele,

and/or (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele, and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4.

[0033] The invention further provides a humanized form of a 10D5 antibody comprising a human heavy chain constant region with L234A, L235A and G237A mutations, wherein positions are numbered by the EU numbering system. Optionally, the isotype is human IgG1, IgG2 or IgG4, preferably IgG1. The 10D5 hybridoma was deposited with the ATCC on April 8, 2003 and assigned accession number PTA-5129. The ATCC is located at 10801 University Blvd., Manassas, VA 20110.

[0034] The invention further provides a humanized form of a 12A11 antibody comprising a humanized light chain variable region of SEQ ID NO: 10 and a humanized heavy chain variable region of SEQ ID NO: 11 and a human heavy chain constant region with L234A, L235A and G237A mutations, wherein positions are numbered by the EU numbering system. Optionally, the isotype is human IgG1, IgG2 or IgG4, preferably IgG1.

[0035] The invention further provides a humanized form of a 3D6 antibody comprising a human heavy chain constant region with L234A, L235A and G237A mutations, wherein positions are numbered by the EU numbering system. The 3D6 hybridoma was deposited with the ATCC on Apr. 8, 2003 and assigned accession number PTA-5130. The ATCC is located at 10801 University Blvd., Manassas, VA 20110. Optionally, the isotype is human IgG1, IgG2 or IgG4, preferably IgG1. The 3D6 hybridoma was deposited with the ATCC on April 8, 2003.

[0036] The invention further provides an isolated humanized antibody comprising a mature light chain variable region sequence of SEQ ID NO: 2 and a mature heavy chain variable region sequence of SEQ ID NO: 3, and a human heavy chain constant region of IgG isotype with L234A, L235A, and G237A mutations, wherein positions are numbered by the EU numbering system. Optionally, the isotype is human IgG1 isotype.

[0037] The invention further provides an isolated humanized form of a 12B4 antibody, wherein the 12B4 antibody is characterized by a mature light chain variable region sequence of SEQ ID NO: 31and a mature heavy chain variable region sequence of SEQ ID NO: 32, and a human heavy chain constant region of IgG isotype with L234A, L235A, and G237A

mutations, wherein positions are numbered by the EU numbering system. Optionally, the isotype is human IgG1 isotype.

[0038] The invention further provides a method of treating or effecting prophylaxis of a disease characterized by Aβ deposits in the brain of patient comprising administering an effective regime of a humanized antibody to the patient; wherein the humanized antibody comprises a mature light chain variable region sequence of SEQ ID NO: 2 and a mature heavy chain variable region sequence of SEQ ID NO: 3, and a human heavy chain constant of IgG1 isotype with L234A, L235A, and G237A mutations, wherein position are numbered by the EU numbering system. Optionally, the patient has at least one ApoE4 allele. Optionally the dose is 0.15-1 mg/kg. Optionally, the dose is 0.15-2 mg/kg. Optionally, the method further comprises monitoring the patient by MRI for vasogenic edema. Optionally, the method is for treating a population of the patients and the regime administered to different patients in the population does not depend on the number of ApoE4 alleles present in a patient.

[0039] The invention further provides a method of effecting prophylaxis of a disease characterized by deposits of Aβ deposits in the brain of a patient comprising administering an effective regime of an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ on administration to a patient, wherein the patient has at least one ApoE4 allele. Optionally, the patient has two ApoE4 alleles. Optionally, the patient is asymptomatic. Optionally, the patient has a mini-mental test score of 27 or higher. Optionally, the patient has a mini-mental test score of 20-26. Optionally, the patient is at least sixty years of age. Optionally, the method further comprises determining the number of ApoE4 alleles in the patient.

[0040] The invention further provides a method of treating or effecting prophylaxis of a disease characterized by amyloid deposits of Aβ in the brain in a patient comprising administering a first regime comprise administering an agent that is an antibody to Aβ or an agent that induces an antibody to Aβ to the patient; monitoring the patient for vasogenic edema; maintaining the first regime if vasogenic edema does not appear; and administering a second regime to the patient if vasogenic edema does appear, wherein the second regime is a reduced dose of the agent and/or a reduced frequency of the agent, and/or a different agent with reduced capacity to bind an Fcγ receptor and/or C1q or is a lack of antibody to Aβ or an agent that induces an antibody to Aβ; wherein the second regime is maintained at least for the

duration of the vasogenic edema. Optionally, the agent in the first regime is an antibody that specifically binds to an epitope within residues 1-11 of Aβ. Optionally, the first regime comprises administering a first antibody to A and the second regime comprises administering a second antibody to Aβ with reduced capacity to find to an Fcγ receptor and or C1q relative to the first antibody. Optionally, the first antibody is bapineuzumab and the second antibody is an L234A, L235A, G237A variant of bapineuzumab.

[0041] The invention further provides a method of treating or effecting prophylaxis of Alzheimer's disease in a patient population, comprising administering an antibody that specifically binds to an epitope within residues 1-11 of Aβ and has mutations in the constant region that reduce binding to an Fcγ receptor and or C1q to the patient, wherein the antibody is administered at the same dose and/or frequency to each patient regardless of the number of ApoE4 alleles in the patient. Optionally, the antibody is an L234A, L235A, and G237A variant of bapineuzumab. Optionally, the method further comprises a step of monitoring the patient for vasogenic edema.

[0042] The invention further provides a method of treating or effecting prophylaxis of Alzheimer's disease in a patient population, comprising administering an agent that is an antibody to Aβ or which induces an antibody to Aβ on administration to some of the patients in the population, wherein patients in the population having zero ApoE4 alleles receive the agent and patients in the population having two ApoE4 alleles do not receive the agent. Optionally, patients in the population having one ApoE4 allele do not receive the agent. Optionally, the antibody is administered by intravenous infusion at a dosage within a range of about 0.15 mg/kg to about 2 mg/kg. Optionally, the antibody is bapineuzumab. Optionally, the dosage is about 0.5 mg/kg. Optionally, the dosage is about 2 mg/kg. Optionally, the brain volume decline is measured by MRI.

[0043] The invention further provides a method of determining a regime for bapineuzumab administration, comprising providing instructions to a healthcare professional that assists the healthcare professional determine a regime of bapineuzumab to administer to a patient having zero copies of an ApoE4 allele. Optionally, the regime is characterized by administering bapineuzumab at a dose of 0.5-2 mg/kg. Optionally, the regime is characterized by administering 0.5-2 mg/kg of bapineuzumab quarterly by intravenous administration, or at a dose frequency and route of administration that generates an equivalent average serum concentration or area under the curve. Optionally, the regime further comprises monitoring

the patient for vasogenic edema. Optionally, the monitoring regime is different than the monitoring regime for a patient having or two copies of an ApoE4 allele. Optionally, the method further comprises the step of determining the number of ApoE4 alleles present in a patient. Optionally, the method further comprises providing bapineuzumab to a healthcare professional. Optionally, the instructions and bapineuzumab are provided in combination. Optionally, the regime further comprises monitoring at the patient for vasogenic edema. Optionally, the monitoring is performed by MRI. Optionally, the monitoring is by brain imaging.

[0044] The invention further provides a method of determining a regime for bapineuzumab administration comprising providing instructions to a healthcare professional that assists the healthcare professional determine a regime of bapineuzumab to administer to a patient having one or two copies of an ApoE4 allele. Optionally, the regime is characterized by administering bapineuzumab at a dose of 0.15-1 mg/kg. Optionally, the regime is characterized by administering bapineuzumab at a dose of 0.15-1 mg/kg quarterly by intravenous administration, or at a dose frequency and route of administration that generates an equivalent average serum concentration or area under the curve. Optionally, the determined regime comprises a first and a second regime, wherein the first regime is administered to the patient before vasogenic edema appears, and the second regime after vasogenic edema has resolved; and wherein the first and second regimes each comprise administering bapineuzumab; wherein the first regime differs relative to the second regime in at least one of (i) - (ii) below: (i) the dose of the bapineuzumab is reduced; (ii) the frequency of administration of the bapineuzumab is reduced. Optionally, the regime further comprises monitoring the patient for vasogenic edema. Optionally, the monitoring regime is different than the monitoring regime for a patient having or two copies of an ApoE4 allele. Optionally, the method further comprises the step of determining the number of ApoE4 alleles present in a patient. Optionally, the method further comprises providing bapineuzumab to a healthcare professional. Optionally, the instructions and bapineuzumab are provided in combination. Optionally, the regime further comprises monitoring at the patient for vasogenic edema. Optionally, the monitoring is performed by MRI. Optionally, the monitoring is by brain imaging. Optionally, the monitoring regime is different than the monitoring regime for a patient having zero copies of an ApoE4 allele. Optionally, the frequency of monitoring is greater for: (a) patients having two copies of the ApoE4 allele relative to patients having zero copies of an ApoE4 allele; (b) patients having one copy of an

ApoE4 allele relative to patients having zero copies of an ApoE4 allele; and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4 allele.

[0045] The invention further provides a kit for determining a regime for bapineuzumab administration comprising instructions to a healthcare professional that assist the healthcare professional determine which regime of bapineuzumab to administer to a patient having zero copies of an ApoE4 allele. Optionally, the instructions specify a regime characterized by administering bapineuzumab at a dose of 0.5-2 mg/kg. Optionally, the instructions specify administering 0.5-2 mg/kg of bapineuzumab quarterly by intravenous administration, or at a dose frequency and route of administration that generates an equivalent average serum concentration or area under the curve. Optionally, the instructions specify monitoring the patient for vasogenic edema. Optionally, the instructions specify that the monitoring regime is different that the monitoring regime for a patient having one or two copies of an ApoE4 allele. Optionally, the instructions specify that the determined regime comprises a first and a second regime, wherein the first regime is administered to the patient before vasogenic edema appears, and the second regime after vasogenic edema has resolved; and wherein the first and second regimes each comprise administering bapineuzumab; wherein the first regime differs relative to the second regime in at least one of (i) - (ii) below: (i) the dose of the bapineuzumab is reduced; (ii) the frequency of administration of the bapineuzumab is reduced. Optionally, the instructions specify determining the number of ApoE4 alleles present in a patient. Optionally, the kit further comprises bapineuzumab. Optionally, the instructions specify monitoring at the patient for vasogenic edema. Optionally, the instructions specify the monitoring is performed by MRI. Optionally, the instructions specify the monitoring is by brain imaging.

[0046] The invention further provides a kit for determining a regime for bapineuzumab administration comprising instructions to a healthcare professional that assist the healthcare professional determine which regime of bapineuzumab to administer to a patient having one or two copies of an ApoE4 allele. Optionally, the instructions specify administering bapineuzumab at a dose of 0.15-1 mg/kg. Optionally, the instructions specify administering bapineuzumab at a dose of 0.15-1 mg/kg quarterly by intravenous administration, or at a dose frequency and route of administration that generates an equivalent average serum concentration or area under the curve. Optionally, the instructions specify that the determined regime comprises a first and a second regime, wherein the first regime is administered to the patient before vasogenic edema appears, and the second regime after

vasogenic edema has resolved; and wherein the first and second regimes each comprise administering bapineuzumab; wherein the first regime differs relative to the second regime in at least one of (i) - (ii) below: (i) the dose of the bapineuzumab is reduced; (ii) the frequency of administration of the bapineuzumab is reduced. Optionally, the instructions specify determining the number of ApoE4 alleles present in a patient. Optionally, the kit further comprises bapineuzumab. Optionally, the instructions specify monitoring at the patient for vasogenic edema. Optionally, the instructions specify the monitoring is performed by MRI. Optionally, the instructions specify the monitoring is by brain imaging. Optionally, the instructions specify the monitoring regime is different that the monitoring regime for a patient having zero copies of an ApoE4 allele. Optionally, the instructions specify that the frequency of monitoring is greater for: (a) patients having two copies of the ApoE4 allele relative to patients having zero copies of an ApoE4 allele; (b) patients having one copy of an ApoE4 allele relative to patients having zero copies of an ApoE4 allele; and/or (c) patients having two copies of an ApoE4 allele relative to patients having one copy of an ApoE4 allele.

[0047] The invention further provides a method for improving the safety of bapineuzumab in patients having one or two ApoE4 alleles, comprising advising the physician to administer a lower dose of bapineuzumab to a patient having one or two ApoE alleles relative to that of a patient having zero ApoE alleles.

[0048] The invention further provides a method for improving the safety of bapineuzumab in patients having one or two ApoE4 alleles, comprising advising the physician to monitor the patient by MRI more frequently than a patient having one or two ApoE alleles relative to that of a patient having zero ApoE alleles.

[0049] The invention further provides an isolated antibody comprising a human heavy chain constant region of isotype IgG1, wherein amino acids at positions 234, 235, and 237 (EU numbering) are each alanine. Optionally, no other amino acid from positions 230-240 or 315-325 in the human heavy chain constant region is occupied by an amino acid not naturally found at that position in a human IgG1 constant region. Optionally, no amino acid in the human heavy chain constant region other than positions 234, 235 and 237 is occupied by an amino acid not naturally found at that position in a human IgG1 constant region. Optionally, the human heavy chain constant region comprise CH1, hinge, CH2 and CH3 regions. Optionally, the human heavy chain constant region has an amino acid sequence comprising SEQ ID NO:66 or SEQ ID NO:67 or an allotype of either of these sequences. Optionally, the human heavy chain constant region has an amino acid sequence comprising SEQ ID NO:66

or SEQ ID NO:67. Optionally, the antibody is a fully human antibody. Optionally, the antibody is a humanized antibody. Optionally, the antibody is chimeric antibody.

BRIEF DESCRIPTION OF THE FIGURES

[0050] Fig. 1 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in treated patients relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo. MITT = modified intent to treat.

[0051] Fig. 2 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in treated patients who completed the trials ("completers") relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo.

[0052] Fig. 3 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in ApoE4 carrier treated patients relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo.

[0053] Fig. 4 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in ApoE4 carrier treated patients who completed the trial relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo.

[0054] Fig. 5 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in ApoE4 non-carrier treated patients relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo.

[0055] Fig. 6 provides similar information to Fig. 5 except that Fig. 6 shows changes based on the MMSE scale relative to placebo.

[0056] Fig. 7 shows changes in ADAS-Cog, DAD, NTB and CDR-SB in ApoE4 non-carrier treated patients who completed the trial relative to placebo patients using a repeated measures statistical model without assumption of linearity. Bars above zero indicate improvement relative to placebo.

[0057] Fig. 8 shows similar information to Fig. 7 except that Fig. 8 shows changed based on the MMSE scale relative to placebo.

[0058] Fig. 9 shows changes in ADAS-cog, DAS, NTB and CDR-SB over time in treated patients compared with placebos in an ApoE4 non-carrier population.

[0059] Figs. 10, 11 and 12 show changes in BBSI in total population (ApoE4 carriers and non-carriers), ApoE4 carriers and ApoE4 non-carriers respectively compared with placebo populations.

[0060] Fig. 13 shows CSF concentration of phospho-tau in treated patients compared with placebo patients (without distinguishing between ApoE4 genotypes).

[0061] Fig. 14 shows changes in serum concentration of bapineuzuab in serum over time (left) and concentration of Aβ in plasma over time.

[0062] Fig. 15 shows an alignment of the CH2 domains of human IgG1 (SEQ ID NO: 95), IgG2 (SEQ ID NO: 96), and IgG4 (SEQ ID NO: 97) with mouse IgG1 (SEQ ID NO: 98) and IgG2a (SEQ ID NO: 99).

[0063] Fig. 16 shows Aβ plaque clearance by mouse microglia of murine 3D6 IgG1 derivatives. MsIgG1 and MsIgG2a are murine antibodies against irrelevant antigens. The 3D6 antibodies have the variable region described herein. 3D6/FcγR1 indicates the single E233P mutant in the Fc binding region of the IgG1 constant region. 3D6/C1q indicates the triple mutant in the C1q binding region. *See, e.g.*, Example 6 and Table 10.

[0064] Fig. 17 shows Aβ plaque clearance by mouse microglia of murine 3D6 IgG2a derivatives. IgG2a is a murine antibody against an irrelevant antigen. The remaining antibodies and conditions are described, *e.g.*, in Example 6 and Table 10.

[0065] Fig. 18 shows Aβ plaque clearance by mouse microglia of humanized 3D6 derivatives (AAB). The antibodies and conditions are described *e.g.*, in Example 6 and Table 10.

[0066] Fig. 19 shows results of an in vitro assay measuring engulfment of murine IgG-coated beads by mouse microglial cells. Conditions are described in Example 6.

[0067] Fig. 20 shows a similar assay using the indicated humanized antibodies. Conditions are described in Example 6.

[0068] Fig. 21 shows results of an ELISA assay measuring C1q binding by the indicated humanized antibodies. *See* Example 7.

[0069] Fig. 22 shows the results of an antibody dependent complement cytotoxicity assay using the indicated humanized antibodies. Results are expressed as described in Example 7.

[0070] Fig. 23 shows results of an ELISA assay measuring C1q binding by the indicated murine antibodies. *See* Example 8.

[0071] Figs. 24-25 show the results of a contextual fear assay in mice treated with the indicated humanized antibodies. Results are compared between wild type and Tg2576 mice, as described in Example 9.

[0072] Fig. 26 shows the results of the ADCC activities of anti-Lewis Y Ab02 antibodies. *See* Example 15.

[0073] Fig. 27 shows the results of the CDC (complement dependent cytotoxicity) activities of anti-Lewis Y Ab02 antibodies. *See* Example 15.

DEFINITIONS

[0074] The term "immunoglobulin" or "antibody" (used interchangeably herein) refers to an antigen-binding protein having a basic four-polypeptide chain structure consisting of two heavy and two light chains, said chains being stabilized, for example, by interchain disulfide bonds, which has the ability to specifically bind antigen. Both heavy and light chains are folded into domains. The term "domain" refers to a globular region of a heavy or light chain polypeptide comprising peptide loops (*e.g.*, comprising 3 to 4 peptide loops) stabilized, for example, by pleated sheet and/or intrachain disulfide bond. Domains are further referred to herein as "constant" or "variable", based on the relative lack of sequence variation within the domains of various class members in the case of a "constant" domain, or the significant variation within the domains of various class members in the case of a "variable" domain. "Constant" domains on the light chain are referred to interchangeably as "light chain constant regions", "light chain constant domains", "CL" regions or "CL" domains). "Constant" domains on the heavy chain are referred to interchangeably as "heavy chain constant regions", "heavy chain constant domains", "CH" regions or "CH" domains). A heavy chain constant region is also commonly understood to refer collectively to the domains present in a full length constant region, which are CH1, hinge, CH2, and CH3 domains in the case of antibodies of IgG isotype. "Variable" domains on the light chain are referred to interchangeably as "light chain variable regions", "light chain variable domains", "VL"

regions or "VL" domains). "Variable" domains on the heavy chain are referred to interchangeably as "heavy chain constant regions," "heavy chain constant domains," "CH" regions or "CH" domains).

[0075] The term "region" refers to a part or portion of an antibody chain and includes constant or variable domains as defined herein, as well as more discrete parts or portions of said domains. For example, light chain variable domains or regions include "complementarity determining regions" or "CDRs" interspersed among "framework regions" or "FRs", as defined herein.

[0076] References to an antibody or immunoglobulin include intact antibodies and binding fragments thereof. Typically, fragments compete with the intact antibody from which they were derived for specific binding to an antigen. Fragments include separate heavy and light chains, Fab, Fab' F(ab')2, Fabc, and Fv. Separate chains include NANOBODIES™ (*i.e.*, the isolated VH fragment of the heavy chain of antibodies from camels or llamas, optionally humanized). Isolated VH fragments can also be obtained from other sources, such as human antibodies. Fragments are produced by recombinant DNA techniques, or by enzymatic or chemical separation of intact immunoglobulins. The term "antibody" also includes one or more immunoglobulin chains that are chemically conjugated to, or expressed as, fusion proteins with other proteins. The term "antibody" also includes bispecific antibody. A bispecific or bifunctional antibody is an artificial hybrid antibody having two different heavy/light chain pairs and two different binding sites. Bispecific antibodies can be produced by a variety of methods including fusion of hybridomas or linking of Fab' fragments. (*See, e.g.*, Songsivilai & Lachmann, *Clin. Exp. Immunol.* 79:315-321 (1990); Kostelny *et al., J. Immunol.* 148, 1547-1553 (1992).)

[0077] "Specific binding" of an antibody means that the antibody exhibits appreciable affinity for antigen or a preferred epitope and, preferably, does not exhibit significant cross reactivity. Appreciable or preferred binding includes binding with an affinity of at least 10^6, 10^7, 10^8, 10^9 M^{-1}, or 10^{10} M^{-1}. Affinities greater than 10^7 M^{-1}, preferably greater than 10^8 M^{-1} are more preferred. Values intermediate of those set forth herein are also intended to be within the scope of the present invention and a preferred binding affinity can be indicated as a range of affinities, for example, 10^6 to 10^{10} M^{-1}, preferably 10^7 to 10^{10} M^{-1}, more preferably 10^8 to 10^{10} M^{-1}. An antibody that "does not exhibit significant cross reactivity" is one that will not appreciably bind to an undesirable entity (*e.g.*, an undesirable proteinaceous entity).

For example, an antibody that specifically binds to Aβ will appreciably bind Aβ but will not significantly react with non-Aβ proteins or peptides (*e.g.*, non-Aβ proteins or peptides included in plaques). An antibody specific for a preferred epitope will, for example, not significantly cross react with remote epitopes on the same protein or peptide. Specific binding can be determined according to any art-recognized means for determining such binding. Preferably, specific binding is determined according to Scatchard analysis and/or competitive binding assays.

[0078] The term "humanized immunoglobulin" or "humanized antibody" refers to an immunoglobulin or antibody that includes at least one humanized immunoglobulin or antibody chain (*i.e.*, at least one humanized light or heavy chain). The term "humanized immunoglobulin chain" or "humanized antibody chain" (*i.e.*, a "humanized immunoglobulin light chain" or "humanized immunoglobulin heavy chain") refers to an immunoglobulin or antibody chain (*i.e.*, a light or heavy chain, respectively) having a variable region that includes a variable framework region (also known as variable region framework) substantially from a human immunoglobulin or antibody and complementarity determining regions (CDRs) (*e.g.*, at least one CDR, preferably two CDRs, more preferably three CDRs) substantially from a non-human immunoglobulin or antibody (*e.g.*, rodent, and optionally, mouse), and further includes constant regions (*e.g.*, at least one constant region or portion thereof, in the case of a light chain, and preferably three constant regions in the case of a heavy chain). The term "humanized variable region" (*e.g.*, "humanized light chain variable region" or "humanized heavy chain variable region") refers to a variable region that includes a variable framework region (also known as a variable region framework) substantially from a human immunoglobulin or antibody and complementarity determining regions (CDRs) substantially from a non-human immunoglobulin or antibody.

[0079] The phrase "substantially from a human immunoglobulin or antibody" or "substantially human" means that, when aligned to a human immunoglobulin or antibody amino sequence for comparison purposes, the region shares at least 80-90% (*e.g.*, at least 90%), preferably 90-95%, more preferably 95-99% identity (*i.e.*, local sequence identity) with the human framework or constant region sequence, allowing, for example, for conservative substitutions, consensus sequence substitutions, germline substitutions, backmutations, and the like. The introduction of conservative substitutions, consensus sequence substitutions, germline substitutions, backmutations, and the like, is often referred to as "optimization" of a humanized antibody or chain. The phrase "substantially from a non-

human immunoglobulin or antibody" or "substantially non-human" means having an immunoglobulin or antibody sequence at least 80-95%, preferably 90-95%, more preferably, 96%, 97%, 98%, or 99% identical to that of a non-human organism, *e.g.*, a non-human mammal.

[0080] Accordingly, all regions or residues of a humanized immunoglobulin or antibody, or of a humanized immunoglobulin or antibody chain, except possibly the CDRs, are substantially identical to the corresponding regions or residues of one or more native human immunoglobulin sequences. The term "corresponding region" or "corresponding residue" refers to a region or residue on a second amino acid or nucleotide sequence which occupies the same (*i.e.*, equivalent) position as a region or residue on a first amino acid or nucleotide sequence, when the first and second sequences are optimally aligned for comparison purposes.

[0081] The terms "humanized immunoglobulin" or "humanized antibody" are not intended to encompass chimeric immunoglobulins or antibodies, as defined *infra*. Although humanized immunoglobulins or antibodies are chimeric in their construction (*i.e.*, comprise regions from more than one species of protein), they include additional features (*i.e.*, variable regions comprising donor CDR residues and acceptor framework residues) not found in chimeric immunoglobulins or antibodies, as defined herein.

[0082] The term "chimeric immunoglobulin" or antibody refers to an immunoglobulin or antibody whose variable regions derive from a first species and whose constant regions derive from a second species. Chimeric immunoglobulins or antibodies can be constructed, for example by genetic engineering, from immunoglobulin gene segments belonging to different species.

[0083] An "antigen" is an entity (*e.g.*, a proteinaceous entity or peptide) to which an antibody specifically binds.

[0084] The term "epitope" or "antigenic determinant" refers to a site on an antigen to which an immunoglobulin or antibody (or antigen binding fragment thereof) specifically binds. Epitopes can be formed both from contiguous amino acids or noncontiguous amino acids juxtaposed by tertiary folding of a protein. Epitopes formed from contiguous amino acids are typically retained on exposure to denaturing solvents whereas epitopes formed by tertiary folding are typically lost on treatment with denaturing solvents. An epitope typically includes at least 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 amino acids in a unique spatial

conformation. Methods of determining spatial conformation of epitopes include, for example, x-ray crystallography and 2-dimensional nuclear magnetic resonance. *See, e.g., Epitope Mapping Protocols in Methods in Molecular Biology,* Vol. 66, G. E. Morris, Ed. (1996).

[0085] Antibodies that recognize the same epitope can be identified in a simple immunoassay showing the ability of one antibody to block the binding of another antibody to a target antigen, *i.e.*, a competitive binding assay. Competitive binding is determined in an assay in which the immunoglobulin under test inhibits specific binding of a reference antibody to a common antigen, such as Aβ. Numerous types of competitive binding assays are known, for example: solid phase direct or indirect radioimmunoassay (RIA), solid phase direct or indirect enzyme immunoassay (EIA), sandwich competition assay (*see* Stahli *et al., Methods in Enzymology* 9:242 (1983)); solid phase direct biotin-avidin EIA (*see* Kirkland *et al., J. Immunol.* 137:3614 (1986)); solid phase direct labelled assay, solid phase direct labelled sandwich assay (*see* Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Press (1988)); solid phase direct label RIA using I-125 label (*see* Morel *et al., Mol. Immunol.* 25(1):7 (1988)); solid phase direct biotin-avidin EIA (Cheung *et al., Virology* 176:546 (1990)); and direct labelled RIA (Moldenhauer *et al., Scand. J. Immunol.* 32:77 (1990). Typically, such an assay involves the use of purified antigen bound to a solid surface or cells bearing either of these, an unlabelled test immunoglobulin and a labelled reference immunoglobulin. Competitive inhibition is measured by determining the amount of label bound to the solid surface or cells in the presence of the test immunoglobulin. Usually the test immunoglobulin is present in excess. Usually, when a competing antibody is present in excess, it will inhibit specific binding of a reference antibody to a common antigen by at least 50-55%, 55-60%, 60-65%, 65-70% 70-75% or more.

[0086] An epitope is also recognized by immunologic cells, for example, B cells and/or T cells. Cellular recognition of an epitope can be determined by *in vitro* assays that measure antigen-dependent proliferation, as determined by ^{3}H-thymidine incorporation, by cytokine secretion, by antibody secretion, or by antigen-dependent killing (cytotoxic T lymphocyte assay).

[0087] Exemplary epitopes or antigenic determinants can be found within the human amyloid precursor protein (APP), but are preferably found within the Aβ peptide of APP. Multiple isoforms of APP exist, for example APP^{695}, APP^{751} and APP^{770}. Amino acids

within APP are assigned numbers according to the sequence of the APP^{770} isoform (*see e.g.*, GenBank Accession No. P05067). The sequences of Aβ peptides and their relationship to the APP precursor are illustrated by Fig. 1 of Hardy *et al.*, TINS 20, 155-158 (1997). For example, Aβ42 has the sequence:

H_2N-Asp-Ala-Glu-Phe-Arg-His-Asp-Ser-Gly-Tyr-Glu-Val-His-His-Gln-Lys-Leu-Val-Phe-Phe-Ala-Glu-Asp-Val-Gly-Ser-Asn-Lys-Gly-Ala-Ile-Ile-Gly-Leu-Met-Val-Gly-Gly-Val-Val-Ile-Ala-OH (SEQ ID NO: 1).

[0088] Unless otherwise apparent from the context, reference to Aβ also includes natural allelic variations of the above sequence, particularly those associated with hereditary disease, such as the Arctic mutation, E693G, APP 770 numbering. Aβ41, Aβ40 and Aβ39 differ from Aβ42 by the omission of Ala, Ala-Ile, and Ala-Ile-Val respectively from the C-terminal end. Aβ43 differs from Aβ42 by the presence of a threonine residue at the C-terminus. Preferred epitopes or antigenic determinants, as described herein, are located within the N-terminus of the Aβ peptide and include residues within amino acids 1-11 of Aβ, preferably from residues 1-10, 1-3, 1-4, 1-5, 1-6, 1-7 or 3-7 of Aβ42. Additional preferred epitopes or antigenic determinants include residues 2-4, 5, 6, 7 or 8 of Aβ, residues 3-5, 6, 7, 8 or 9 of Aβ, or residues 4-7, 8, 9 or 10 of Aβ42. Other preferred epitopes occur within central or C-terminal regions as described below.

[0089] An N-terminal epitope of Aβ means an epitope with residues 1-11. An epitope within a C-terminal region means an epitope within residues 29-43, and an epitope within a central regions means an epitope with residues 12-28

[0090] "Soluble" or "dissociated" Aβ refers to non-aggregating or disaggregated Aβ polypeptide.

[0091] "Insoluble" Aβ refers to aggregating Aβ polypeptide, for example, Aβ held together by noncovalent bonds. Aβ (*e.g.*, Aβ42) is believed to aggregate, at least in part, due to the presence of hydrophobic residues at the C-terminus of the peptide (part of the transmembrane domain of APP). One method to prepare soluble Aβ is to dissolve lyophilized peptide in neat DMSO with sonication. The resulting solution is centrifuged to remove any insoluble particulates.

[0092] The term "Fc region" refers to a C-terminal region of an IgG antibody, in particular, the C-terminal region of the heavy chain(s) of said IgG antibody. Although the boundaries of

the Fc region of an IgG heavy chain can vary slightly, a Fc region is typically defined as spanning from about amino acid residue Cys226 to the carboxyl-terminus of an IgG heavy chain(s).

[0093] The term "effector function" refers to an activity that resides in the Fc region of an antibody (*e.g.*, an IgG antibody) and includes, for example, the ability of the antibody to bind effector molecules such as complement and/or Fc receptors, which can control several immune functions of the antibody such as effector cell activity, lysis, complement-mediated activity, antibody clearance, and antibody half-life. Effector function can also be influenced by mutations in the hinge region.

[0094] The term "effector molecule" refers to a molecule that is capable of binding to the Fc region of an antibody (*e.g.*, an IgG antibody) including a complement protein or a Fc receptor.

[0095] The term "effector cell" refers to a cell capable of binding to the Fc portion of an antibody (*e.g.*, an IgG antibody) typically *via* an Fc receptor expressed on the surface of the effector cell including, but not limited to, lymphocytes, *e.g.*, antigen presenting cells and T cells.

[0096] The term "Kabat numbering" unless otherwise stated, is defined as the numbering of the residues as in Kabat *et al.* (Sequences of Proteins of Immunological Interest, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, Md. (1991)), incorporated herein by reference.

[0097] The term "Fc receptor" or "FcR" refers to a receptor that binds to the Fc region of an antibody. Typical Fc receptors which bind to an Fc region of an antibody (*e.g.*, an IgG antibody) include, but are not limited to, receptors of the FcγRI, FcγRII, and FcγRIII subclasses, including allelic variants and alternatively spliced forms of these receptors. Fc receptors are reviewed in Ravetch and Kinet, Annu. Rev. Immunol 9:457-92 (1991); Capel *et al.*, Immunomethods 4:25-34 (1994); and de Haas *et al.*, J. Lab. Clin. Med. 126:330-41 (1995).

[0098] The term "adjuvant" refers to a compound that when administered in conjunction with an antigen augments and/or redirects the immune response to the antigen, but when administered alone does not generate an immune response to the antigen. Adjuvants can

augment an immune response by several mechanisms including lymphocyte recruitment, stimulation of B and/or T cells, and stimulation of macrophages.

[0099] The area under the curve (AUC) is the area under the curve in a plot of concentration of drug in plasma against time. In an indiviudal patient, the area under the curve represents the area under the curve based on that patient. In a population of patients, the area under the curve represents the mean area under the curve for a comparable time interval of different patients in the population.

[0100] The mean serum concentration in an indiviual patient represents the mean concentration of an antibody (or induced antibodies for an active agent) over a period of time. The mean serum concentration in a population of patients represents the mean of the mean serum concentrations of the individual patients over comparable periods of time.

[0101] The maximum serum concentration in an individual patient represents the maximum concentration of an antibody (or induced antibodies for an active agent) during a course of treatment. The maximum serum concentration in a population of indidvuals represents the mean of maximum concentrations of the antibody or induces antibodies between individuals in the population.

[0102] For brevity, the term "ApoE4 carrier" is sometimes used to refer to patients havine one or two ApoE4 alleles and "ApoE4 noncarrier", ApoE4 non-carrier" or "non-ApoE4 carrier" to refer to patients having zero ApoE4 alleles.

DETAILED DESCRIPTION OF THE INVENTION

I. General

[0103] The invention provides methods of immunotherapy of Alzheimer's and similar diseases in which the regime administered to a patient depends on the ApoE genotype of the patient. The methods are based in part on (1) the observation that certain immunotherapy regimes lead to higher instances in the appearance of vasogenic edema (VE) in patients having an ApoE4 allele (E4) than in patients lacking an E4 allele, and more frequently still in patients having two E4 alleles, and/or (2) the initial observation of differential efficacy in ApoE4 carrier patients compared to ApoE4 non-carrier patients or patients receiving at least six doses compared to patients receiving less than six doses. The results also show that frequency of cases of vasogenic edema increases with dose frequency and amount.

[0104] Although practice of the invention is not dependent on an understanding of mechanism, it is hypothesized that the association of the vasogenic edema with an ApoE4 genotype may stem from a greater deposition of Aβ deposits and hence induction of a greater clearing response when antibodies bind to the deposits. Clearing of amyloid deposits may lead to vasogenic edema by any or all of several mechanisms. Removal of amyloid from blood vessel walls (vascular amyloid) may cause leakiness of blood vessels; more amyloid in perivascular space may cause slower drainage of interstitial fluid, and/or net increased flow of amyloid from intravascular compartment to brain parenchyma may lead to osmotic gradients. Although vasogenic edema effect is usually asymptomatic and reversible and does not preclude further treatment, it is desirable nevertheless to adjust the therapeutic regime to reduce the risk of vasogenic edema occurring.

[0105] The invention thus provides methods in which the immunotherapy regime is varied, for example to adjust the phagocytic response, depending on the ApoE status of the patient. Although the phagocytic response is useful in clearing amyloid deposits, the response, can optionally be controlled to avoid vasogenic edema. In general, patients having two E4 alleles, who are most susceptible to the vasogenic edema are administered either a lower dose or a lower frequency of the same agent as patients with zero E4 alleles, or are administered a different agent that is less prone to induce a phagocytic response or receive the agent through an alternate mode of administration, such as, for example, subcutaneous administration. Patients with one E4 allele can be treated the same as either patients with zero or two E4 alleles or a treatment can be customized for them in which the dose and/or frequency of administration is intermediate between that administered to patients with zero or two ApoE4 alleles.

II. APOE

[0106] Human ApoE has the UniProtKB/Swiss-Prot entry accession number P02649. The E2, E3, and E4 variants are described in *Genomics* 3:373-379(1988), *J. Biol. Chem.* 259:5495-5499 (1984); and *Proc. Natl. Acad. Sci. U.S.A.* 82:3445-3449(1985). Association of the E4 form with late onset Alzheimer's disease has been reported by *e.g.*, Corder, *Science* 261, 921-3 (1993); Farrer, JAMA, 278, 1349-56 (1997); and Saunders, *Neurology* 43, 1467-72 (1993). The allelic forms present in any individual can be determined by many conventional techniques, such as direct sequencing, use of GeneChip® arrays or the like, allele-specific probes, single-base extension methods, allelic specific extension. Allelic

forms can also be determined at the protein level by ELISA using antibodies specific for different allelic expression products. Kits for genetic and immunological analysis are commercially available (*e.g.*, Innogenetics, Inc.; Graceful Earth, Inc.). Determination of allelic forms are usually made in vitro, that is, on samples removed and never returned to a patient.

III. Different Strategies for Treating or Monitoring depending on ApoE

A. Different Treatment Regimes

[0107] Some immunotherapy regimes for immunotherapy of Alzheimer's and other diseases have been associated with vasogenic edema (VE) in the brain of some patients. Generally, the incidence of VE is greater in ApoE4 carriers than in ApoeE4 non-carriers and in patients receiving higher doses of certain agents in certain immunotherapy regimes. VE has been observed on magnetic resonance imaging (MRI) as high signal intensities on the fluid-attenuated inversion recovery (FLAIR) sequence involving cerebral abnormalities and gyral swelling. VE generally is observed after the first or second administration of the immunotherapeutic agent, although it has been observed after the third or fourth administration. Most patients with VE discovered on MRI are asymptomatic. VE is heterogeneous on presentation, and MRI findings in a particular patient may vary over time. The gyral swelling and to some extent, the larger magnetic resonance (MR) changes seen on FLAIR differentiate VE from the commonly observed white matter changes seen on FLAIR in both normal elderly and Alzheimer's disease patients (Hentschel *et al.*, 2005; de Leeuw *et al.* 2001).

[0108] Vasogenic edema (VE) is characterized by an increase in extracellular fluid volume due to increased permeability of brain capillary endothelial cells to macromolecular serum proteins (*e.g.*, albumin). VE may be the result of increased brain capillary permeability. Clinical symptoms observed in patients with VE, when existent, are varied and to date have been largely mild in nature. Of the cases of VE observed on regularly scheduled MRI, the majority of patients are asymtomatic. Clinical observations associated with the symptomatic cases of VE have included altered mental states (*e.g.*, increased confusion, lethargy, disorientation, and hallucinations), vomiting, headache, gait difficulties, visual distrubances, fatigue, irritability, ataxia, decreased appetite, and diarrhea.

[0109] As summarized above, the invention provides different treatment regimes depending on whether a patient has zero, one or two E4 alleles. Thus, in a population of

treated individuals, those having zero E4 alleles can be treated differently from those having two alleles. Those having one E4 allele can be treated differently (in an intermediate fashion) to those with either zero or two E4 alleles or can be grouped with individuals having zero or two the E4 allele in any of the regimes that follow. It follows that individuals having one E4 allele can be treated differently than individuals with zero alleles and/or that individual with two ApoE4 alleles can be treated differently than individuals with one ApoE4 allele. Ongoing experience with some immunotherapeutic agents suggests that VE is more likely to occur at doses greater than 5 mg/kg (*see* PCT/US07/09499).

[0110] In some methods, ApoE4 status is the only genetic marker determining different treatment regimes in different patients. In other methods, differential treatment regimes can be based on ApoE4 in combination with other genetic markers associated with Alzheimer's disease susceptibility or resistance.

[0111] A population of treated individuals optionally has sufficient total number of patients and sufficient numbers of subpopulations with different numbers of ApoE4 alleles that an association between different treatment regimes and different ApoE4 alleles can be seen relative to a random assignment of the different regimes with a statistical confidence of at least 95%. For example, the treated population can consist of at least 100, 500 or 1000 individuals of who 10-70% and more typically 30-50% have at least one an ApoE4 allele. A treated population can also (*i.e.*, optionally) be recognized as the total population treated with a particular drug produced by a particular manufacturer.

[0112] In some methods, as discussed in greater detail below, individuals having zero ApoE4 alleles are administered an agent in a regime designed to achieve efficacy as assessed from one or more clinical endpoints, such as, for example, cognitive measures (*e.g.*, ADAS-cog, NTB, DAD, MMSE, CDR-SB, NPI), biomarkers (*e.g.*, CSF tau), and brain volume (*e.g.*, BBSI, VBSI), as well as other parameters, such as, for example desirable safety, pharmacokinetics and pharmacodynamics. In some methods, one or two E4 alleles are administered a reduced dose and/or frequency of the same agent as individuals with zero E4 alleles. A goal of such method is to deliver a reduced mean serum concentration of the agent over a period of time (reduced area under the curve) and/or to reduce the maximum peak concentration. This can be accomplished for example, by reducing the dose and administering at the same frequency, or reducing the frequency and administering at the same dose or administering at reduced dose and frequency. If the dose is reduced but the

frequency kept constant, the dose is usually reduced between 10-90%, often about 30-75 or 40-60%. If the frequency is reduced, but the dose kept constant, then the frequency is typically reduced between two and five fold. Sometimes, the frequency is reduced by simply omitting an occasional dose or two consecutive doses from the regime administered to patients with zero ApoE4 alleles. Such doses can for example be omitted during the period a patient is experiencing vasogenic edema.

[0113] In other methods, individual having one or two E4 alleles are administered a reduce dose of the agent at an increased frequency relative to individuals having zero E4 alleles. For, example, the dose can be halved and the frequency doubled. In such methods, the total drug delivered to the two subpopulations over time (*i.e.*, area under the curve) can be the same within experimental error, but the maximum plasma concentration is lower in individuals having two E4 alleles. For example, in patients having one or two E4 alleles the maximum serum concentration of antibody is preferably below 14 μg/ml and for patients having zero alleles, the maximum serum concentration of antibody is preferably below 28 μg/ml.

[0114] In other methods, treatment is administered at different stages relative to disease progression depending on ApoE4 status. In such methods, treatment is administered earlier in patients having two ApoE4 alleles relative to patients having zero ApoE4 alleles or in patients having one ApoE4 allele relative to patients having zero ApoE4 alleles and/or in patients having two ApoE4 alleles relative to patients having one ApoE4 allele. Disease progression can be measured by *e.g.*, the MMSE scale on which a score of 27 to 20 is considered normal, and 20-26 considered mild Alzheimer's. Thus, for example, the mean MMSE score of non-ApoE4 carriers on commencement of treatment can be higher than that of ApoE4 carriers (patients with one or two ApoE4 alleles). Optionally, treatment of ApoE4 carriers can be begun prophylactically before clinical symptoms are evident. Such patients can be identified by screening populations for ApoE4 status. Treatment can be commenced on detecting such status or subsequently when the patient reaches a certain age (*e.g.*, 55, 60 or 65 years) when there is a high risk of Alzheimer's developing. Although understanding of mechanism is not required for practice of such methods, it is believed that early treatment of ApoE4 carriers may be beneficial because the ApoE4 allele reduces capacity to repair neuronal damage, and/or because deposition of Aβ is greater in such patients.

[0115] In some methods, treatment is administered by a different route in patients having zero ApoE4 alleles and patients having one ApoE4 allele and/or patients having two ApoE4 alleles. For example, treatment can be administered intravenously in patients having zero ApoE4 alleles and subcutaneously in patients having one or two alleles. The dosage is typically greater and/or frequency of administration less in such non-ApoE4 carrier patients relative to ApoE4 carrier patients.

[0116] In some methods, a positive response to treatment (*i.e.*, inhibition of cognitive decline or inhibition of decline in brain volume) takes longer to develop in ApoE4 carriers than non-carriers. The greater time may reflect reduced capacity for neuronal repair and/or greater amyloid burden in such patients; and/or use of a less potent treatment regime. In such methods, treatment can be administered for at least one year and optionally at least 2, 3 or 4 years before ceasing treatment for lack of effect. In some methods, treatment is administered for at least six quarterly administrations.

[0117] As noted, agents are sometimes provided with a label contraindicating use in ApoE4 carriers. Such agents can be used in methods of treatment in which only non-ApoE4 carriers receive an agent of the invention (*i.e.*, an antibody that binds to Aβ or an agent that induces such an antibody). In such methods ApoE4 carriers do not receive an antibody that binds to Aβ or an agent that induces such an antibody but can receive other treatments such memantine.

[0118] Methods in which dose and/or frequency of administration are reduced depending on ApoE4 are most useful for agents that initiate a clearing response against amyloid deposits. In general, such agents are antibodies binding to an epitope within Aβ1-11, and which have an Fc region, or fragments of Aβ that induce such antibodies (*i.e.*, contain an epitope within Aβ1-11). Antibodies binding to epitopes within central or C-terminal regions of Aβ usually bind predominantly to soluble forms of Aβ rather than amyloid deposits, and thus initiate little, if any clearing response against amyloid deposits, particularly dense or vascular deposits.

[0119] Examples of suitable dosages ranges and frequencies for administration are provided below. Different dosages and/or frequencies of administration for patients with different E4 status can be selected from within such ranges of dose and frequency. For example, patients with one or two E4 alleles can be administered a dose of 0.1 to 1 mg/kg antibody by intravenous infusion every thirteen weeks, and patients with zero E4 alleles can

be administered a dose of 1 to 2 mg/kg every thirteen weeks. Optionally, patients with two E4 alleles are administered a dose of 0.15 to 0.5 mg/kg, patients with one E4 allele are administered a dose of 0.15 to 1 mg/kg (*e.g.*, 0.5 to 1 mg/kg) and patients with zero E4 alleles are administered a dose of 0.15-2 mg/kg (*e.g.*, 1-2 mg/kg) every thirteen weeks. In a preferred regime, patients with one or two E4 alleles are administered a dose of 0.5 mg/kg of an antibody binding to an epitope within residues 1-11 of Aβ (*e.g.*, bapineuzumab) and patients with zero E4 alleles a dose of 2 mg/kg. The doses are administered intravenously at quarterly intervals until vasogenic edema appears (if it does). After vasogenic edema appears, the next dose is missed and thereafter, patients return to the quarterly dosing schedule at a lower dose of 0.15 mg/kg. If vasogenic edema appears again treatment can be terminated. Patients with zero E4 alleles are administered a dose of 0.5-2 mg/kg, with individually patients with zero E4 alleles optionally receiving doses of 0.5 mg/kg, 1.0 mg/kg, 1.5 mg/kg and 2.0 mg/kg.

[0120] As another example, patients with two E4 alleles are given a first dose of 0.5 mg/kg, and subsequent doses of 1 mg/kg. Alternatively, patients with two E4 alleles are given a first dose of 0.5 mg/kg, second and third doses of 1 mg/kg and subsequent doses of 2.0 mg/kg.

[0121] As another example, patients with zero E4 alleles can be administered a dose of 0.015-0.2 mg/kg antibody subcutaneously once per week and patients with two E4 alleles can be administered the same dose every two weeks. Equivalent regimes to any of the above can be devised by varying either the amount or frequency or route of administration to deliver the same area under the curve (*i.e.*, mean dose integrated with time) of antibody to the serum.

[0122] In some methods, patients with one or two E4 alleles are administered agent to achieve a lower mean serum concentration of antibody over time than patients with zero E4 alleles. The lower mean serum concentration is maintained over a period of at least one or threes month, and usually three months to one year, or indefinitely. The mean serum concentration of all such patients is preferably within the range 2-7 μg antibody/ml serum with that for patients with one or two E4 alleles being lower than that for patients with zero E4 alleles. For example patients with zero E4 alleles can be administered to achieve a mean serum concentration of antibody within a range of 4.5-7 μg antibody/ml and patients with one or two E4 alleles can be administered agent to achieve a mean serum concentration in the range of 2-4.5 μg antibody/ml.

[0123] In such methods, individuals within any subpopulation defined by presence of two, one or zero E4 alleles are usually administered the same regime. However, the regime can also be customized for individuals within a subpopulation. In this case, the mean dose and/or frequency and/or average serum concentration and/or maximum concentration of agent or antibodies induced by the agent in a subpopulation of individuals with two E4 alleles is lower than that of individuals having zero E4 alleles.

[0124] In some methods, a different agent is administered to individuals with two E4 alleles than individuals with zero E4 alleles. The different agents usually differ in their capacity to induce a clearing response against amyloid deposits (*i.e.*, preexisting deposits). Such a capacity can be tested, for example, in an *ex vivo* clearing assay as described by US 6,750,324. In brief, an antibody and microglial cells are incubated with an amyloid deposit from a diseased Alzheimer's patient or transgenic mouse model, and the clearing reaction is monitored using a labelled antibody to Aβ. Clearing capacity of active agents can be similarly tested using sera induced by the active agent as a source of antibody for the assay. Clearing capacity of both passive and active agents can also be evaluated in a transgenic mouse model as also described US 6,750,324 or in a human patient by MRI monitoring. Optionally, the clearing response is measured in an assay that distinguishes between compact and diffuse amyloid deposits. Differences in clearing capacity of some antibodies are more evident or only evident when the comparison is made with respect to clearing capacity of compact amyloid deposits. Optionally, the clearing response is evaluated from a reduction in clearing of vascular amyloid of a mutated antibody relative to an isotype matched otherwise-identical antibody. Vascular amyloid clearing can be assessed by a statistical significant difference between populations of animal models or human patients treated with a mutated antibody and an otherwise-identical isotype-matched antibody without the mutations.

[0125] Additionally or alternatively to assays measuring a clearing response, some antibodies suitable for use in the methods of the invention can be recognized by reduced binding to C1q and/or to Fcγ receptor(s). Capacity to bind C1q and/or an Fcγ receptor can be reduced by mutations near the hinge region of a heavy chain as discussed in more detail below. Reduced capacity can be determined, for example, by comparing a mutated antibody with an isotype matched otherwise identical antibody lacking the mutation(s) present in the mutated antibody (*i.e.*, having residues from a wild type human constant region (*e.g.*, bapineuzumab vs. AAB-003), or by comparing otherwise identical antibodies having different isotypes (*e.g.*, human IgG1 versus human IgG4).

[0126] Some antibodies having reduced capacity to bind C1q and/or Fcγ receptor(s) reduce micro-hemorrhaging relative to isotype matched controls but retain at least some activity in inhibiting cognitive decline and/or clearing amyloid deposits. In some antibodies, reduced amyloid clearing capacity is mainly associated with reduced clearing capacity of vascular amyloid and/or compact amyloid deposits and not with diffuse amyloid deposits. Such antibodies offer a potentially improved efficacy:side-effects profile, particularly for use in ApoE4 carriers.

[0127] Antibodies having reduced binding to C1q and/or an Fcγ receptor can be used in differential methods of treatment as described above. For example, an antibody with reduced binding to C1q and/or and Fcγ receptor can be administered to patients having one or two ApoE4 alleles and an otherwise identical antibody without the mutation(s) to patients with zero ApoE4 alleles. Alternatively, an antibody with reduced binding to C1q and/or an Fcγ receptor can be administered to patients irrespective of the number of ApoE4 alleles.

[0128] Antibodies with constant regions mutated to reduce C1q and/or Fcγ receptor binding are sometimes administered at higher dosages than otherwise identical antibodies without the mutation. For some such antibodies, the dosage can be adjusted upward to achieve an equivalent therapeutic effect with reduced side effects.

[0129] Clearing capacity is affected both by the epitope specificity of an antibody (or antibodies induced by a fragment for active administration) and on the presence of, and type of effector function of the antibody, in particular by the capacity of the Fc region if present to bind to Fcγ receptors. Although clearing amyloid deposits is one useful mechanism of action, agents that lack the capacity to clear deposits can be useful by other mechanisms, such as binding to soluble Aβ and/or soluble oligomeric forms of Aβ. Such binding may reduce toxicity of such species and/or inhibit their aggregating to form deposits among other possible mechanisms.

[0130] Agents with a propensity to induce such a clearing response include antibodies binding to an epitope within residues 1-11 and particularly 1-7 of Aβ, particularly such antibodies having a human IgG1 isotype, which interacts most strongly with Fcγ receptors. Fragments of Aβ that contain epitopes within residues 1-11 and particularly 1-7 are similarly effective in inducing a clearing response. Optionally, agents which initiate a clearing response, can be provided with a label contraindicating use to patients with one or two ApoE4 alleles. Agents with less or no propensity to induce a clearing response include

antibodies to Aβ that have isotypes other than human IgG1, antibodies that lack an Fc region (*e.g.*, Fab fragments, Fv fragments, or Nanobodies), or antibodies with Fc regions mutated by genetic engineering to reduce interactions with Fcγ receptors. Such agents also include antibodies that specifically bind to an epitope within a region of Aβ other than residues 1-11, (*i.e.*, to a mid-epitope or C-terminal epitope, as described above) and antibodies that specifically bind to soluble or oligomeric forms of Aβ without binding to amyloid deposits. Such agents also include fragments of Aβ that lack epitopes within residues 1-11 of Aβ. In such methods, individuals having two E4 alleles are administered an agent with a lower tendency to induce a phagocytic clearing response than individuals having zero alleles. For example, individuals having zero E4 alleles can be administered an antibody binding to an epitope within residues 1-11 of Aβ and having human IgG1 isotype and individuals having two E4 alleles can be administered the same antibody except that the antibody is a Fab fragment or has an isotype other than human IgG1 or has an engineered Fc region to reduce binding to Fcγ receptors. The agent administered to individuals having two E4 alleles can also be an antibody to a mid or C-terminal epitope of Aβ or a fragment of Aβ from a mid or C-terminal region (*i.e.*, lacking an epitope from within Aβ1-11).

[0131] In some methods, patients with two E4 alleles are administered an antibody having an epitope within a mid or C-terminal regions for one or more initial doses and an antibody having an epitope within an N-terminal region for subsequent doses. Such an antibody can be a humanized 266 antibody, a humanized 2H6 antibody, a deglycosylated humanized 2H6 antibody or RN1219. Such an antibody can also be a humanized antibody that specifically binds to an epitope within Aβ28-40 or Aβ33-40. The initial doses preferably consist of 1, 2 or 3 doses. Patients having zero alleles can be administered an antibody having an epitope within an N-terminal region.

[0132] The different regimes administered to different patients depending on their E4 status can be maintained indefinitely. However, such is not usually necessary. It has been found that the vasogenic edema side effect associated with the E4 allele usually occurs by the third dose, if at all. Thus, once patients have received about 2-3 doses of treatment, patients having one or two ApoE4 alleles who have not developed vasogenic edema probably will not develop it, and can thereafter, if desired, be treated by the same regime as patients having zero E4 alleles. Likewise patients with one or two ApoE4 alleles who do develop vasogenic edema notwithstanding the present differential treatment regime usually resolve this condition and can thereafter, if desired, be treated in similar fashion to patients having zero

E4 alleles. Optionally, the dose is titrated up after recovering from vasogenic edema to that used for non-carriers.

[0133] Vasogenic edema typically resolves of its own accord. However, resolution can be facilitated if desired by administration of a corticosteroid.

[0134] Agents can be packaged with labels indicating differential treatment procedures dependent on ApoE4 status consistent with any of the above regimes or combinations thereof.

B. Different Monitoring Regimes

[0135] Alternatively or additionally, the invention provides different monitoring regimes for patients depending on their E4 status. Vasogenic edema is an increase in brain volume from leakage of plasma into the interstitial space. Once extravasated, fluid is retained outside the vasculature, mostly in the white matter of the brain. Vasogenic edema can be monitored by brain imaging particularly by MRI, Positron Emission Tomography (PET Imaging) or Fluid Attenuated Inversion Recovery (FLAIR) sequence imaging (*See Pediatric Neurology,* 20(3):241-243; *AJNR,* 26:825-830; *NEJM,* 334(8):494-500; *Pediatr Nephrol,* 18:1161-1166; *Internal Medicine Journal,* 35:83-90; *JNNP,* 68:790-79 1; *AJNR,* 23:1038-1048; *Pak J Med Sci,* 21(2):149-154 and, *AJNR,* 21:1199-1209*)*. Vasogenic edema presents with a high signal intensity in white matter. The vasogenic edema observed is often asymptomatic but can also be accompanied by headache, nausea, vomiting, confusion, seizures, visual abnormalities, altered mental functioning, ataxia, frontal symptoms, parietal symptoms, stupor, and focal neurological signs.

[0136] According to the present methods, patients with two E4 alleles can be subjected to brain imaging more frequently than patients having zero E4 alleles. For example, patients with two copies of E4 can be imaged before beginning treatment and quarterly thereafter, whereas patients with zero E4 alleles can be imaged before beginning treatment and annually or biannually thereafter. Alternatively, brain imaging can be omitted altogether in patients having zero E4 alleles. Patients having one E4 allele can be imaged with intermediate frequency between patients having zero and two E4 alleles, or can be grouped with patients having either zero or two E4 alleles. It follows that patients with one E4 allele can be monitored differently (*e.g.*, more frequently) than patients with zero E4 alleles and patients with two E4 alleles can be monitored differently (*e.g.*, more frequently) than patients with one E4 allele.

[0137] In patients developing vasogenic edema, monitoring can be continued during the vasogenic edema and for about a year after symptoms resolve. Thereafter, assuming no neurologic findings, monitoring can optionally be performed six monthly or annually.

[0138] Agents can be packaged with labels indicating differential monitoring procedures dependent on ApoE4 status consistent with any of the above regimes or combinations thereof.

C. Universal Treatment or Monitoring Regimes

[0139] Although ApoE4 carriers and non-carriers can have different responses to treatment as discussed above, and some treatment regimes that are safe and effective in ApoE4 carriers are also safe and effective, although not necessarily optimal, in non-ApoE4 carriers and can be used in both types of patients without regard to ApoE status of the patients. In some such regimes, the agent is an antibody that binds to an N-terminal epitope of Aβ having mutation(s) in its constant region that reduce binding to an Fcγ receptor and/or C1q. AAB-003 is an example of such an antibody. In other regimes, the dose and/or frequency and/or the maximal serum concentration and/or mean serum concentration of an administered or induced antibody are constrained within limits as described in PCT/US2007/009499 and further summarized below to reduce the risk of vasogenic edema.

IV. Agents

A. Antibodies

[0140] A variety of antibodies to Aβ have been described in the patent and scientific literature for use in immunotherapy of Alzheimer's disease, some of which are in clinical trials (*see, e.g.*, US 6,750,324). Such antibodies can specifically bind to an N-terminal epitope, a mid (*i.e.*, central)-epitope or a C-terminal epitope as defined above. Some antibodies are N-terminal specific (*i.e.*, such antibodies specifically bind to the N-terminus of Aβ without binding to APP). As noted above antibodies binding to epitopes within residues 1-10, 1-3, 1-4, 1-5, 1-6, 1-7 or 3-7 of Aβ42 or within residues 2-4, 5, 6, 7 or 8 of Aβ, or within residues 3-5, 6, 7, 8 or 9 of Aβ, or within residues 4-7, 8, 9 or 10 of Aβ42 can be used. Some antibodies are C-terminal specific (*i.e.*, specifically bind to a C-terminus of Aβ without binding to APP) Antibodies can be polyclonal or monoclonal. Polyclonal sera typically contain mixed populations of antibodies specifically binding to several epitopes along the length of APP. However, polyclonal sera can be specific to a particular segment of Aβ such as Aβ1-11) without specifically binding to other segments of Aβ. Preferred antibodies are

chimeric, humanized (including veneered antibodies) (*see* Queen *et al.*, *Proc. Natl. Acad. Sci. USA* 86:10029-10033 (1989) and WO 90/07861, US 5,693,762, US 5,693,761, US 5,585,089, US 5,530,101 and Winter, US 5,225,539), or human (Lonberg *et al.*, WO 93/12227 (1993); US 5,877,397, US 5,874,299, US 5,814,318, US 5,789,650, US 5,770,429, US 5,661,016, US 5,633,425, US 5,625,126, US 5,569,825, US 5,545,806, *Nature* 148, 1547-1553 (1994), *Nature Biotechnology* 14, 826 (1996), Kucherlapati, WO 91/10741 (1991)) EP1481008, Bleck, Bioprocessing Journal 1 (Sept/Oct. 2005), US 2004132066, US 2005008625, WO 04/072266, WO 05/065348, WO 05/069970, and WO 06/055778.

[0141] 3D6 antibody, 10D5 and variants thereof are examples of antibodies that can be used. Both are described in US 20030165496, US 20040087777, WO 02/46237, and WO 04/080419, WO 02/088306 and WO 02/088307. 10D5 antibodies are also described in US 20050142131. Additional 3D6 antibodies are described in US 20060198851 and PCT/US05/45614. 3D6 is a monoclonal antibody (mAb) that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 1-5. By comparison, 10D5 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 3-6. A cell line producing the 3D6 monoclonal antibody (RB96 3D6.32.2.4) was deposited with the American Type Culture Collection (ATCC), Manassas, VA 20108, USA on April 8, 2003 under the terms of the Budapest Treaty and assigned assigned accession number PTA-5130. A cell line producing the 10D5 monoclonal antibody (RB44 10D5.19.21) was deposited with the ATCC on April 8, 2003 under the terms of the Budapest Treaty and assigned accession number PTA-5129.

[0142] Bapineuzumab (International Non-Proprietary Name designated by the World Health Organization) means a humanized 3D6 antibody comprising a light chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 2 and a heavy chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 3. (The heavy and light chain constant regions of the antibody designated bapineuzumab by WHO are human IgG1 and human kappa respectively.) A humanized light chain including variable and constant regions is designated SEQ ID NO: 48 below, and a humanized heavy chain including variable and constant regions is designated SEQ ID NO: 66 or 67 (SEQ ID NO: 66 having an additional C-terminal lysine relative to SEQ ID NO: 67).

[0143] Humanized 3D6 Light Chain Variable Region

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Lys Ser Ser Gln Ser Leu Leu Asp Ser Asp Gly Lys Thr Tyr Leu Asn Trp Leu Leu Gln Lys Pro Gly Gln Ser Pro Gln Arg Leu Ile Tyr Leu Val Ser Lys Leu Asp Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Trp Gln Gly Thr His Phe Pro Arg Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys (SEQ ID NO: 2)

[0144] Humanized 3D6 Heavy Chain Variable Region

Glu Val Gln Leu Leu Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Asn Tyr Gly Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala Ser Ile Arg Ser Gly Gly Gly Arg Thr Tyr Tyr Ser Asp Asn Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Val Arg Tyr Asp His Tyr Ser Gly Ser Ser Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser (SEQ ID NO: 3)

[0145] A second version of humanized 3D6 antibody comprising a light chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 4 and a heavy chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 5 is shown below.

[0146] Humanized 3D6 Light Chain Variable Region

Tyr Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Lys Ser Ser Gln Ser Leu Leu Asp Ser Asp Gly Lys Thr Tyr Leu Asn Trp Leu Leu Gln Lys Pro Gly Gln Ser Pro Gln Arg Leu Ile Tyr Leu Val Ser Lys Leu Asp Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Trp Gln Gly Thr His Phe Pro Arg Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys (SEQ ID NO: 4)

[0147] Humanized 3D6 Heavy Chain Variable Region

Glu Val Gln Leu Leu Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Asn Tyr Gly Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala Ser Ile Arg Ser Gly Gly Gly Arg Thr Tyr Tyr Ser Asp Asn Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ala Lys Asn Ser Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Leu Tyr Tyr Cys Val Arg Tyr

Asp His Tyr Ser Gly Ser Ser Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser (SEQ ID NO: 5)

[0148] A third version of humanized 3D6 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 6 and a heavy chain having the amino acid sequence designated SEQ ID NO: 7 is described in US 2005/0090648 A1 published on April 28, 2005 issued as US 7,318,923, which is incorporated herein by reference for all purposes.

[0149] Humanized 3D6 Light Chain

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Leu Gly Gln Pro Ala Ser Ile Ser Cys Lys Ser Ser Gln Ser Leu Leu Asp Ser Asp Gly Lys Thr Tyr Leu Asn Trp Leu Gln Gln Arg Pro Gly Gln Ser Pro Arg Arg Leu Ile Tyr Leu Val Ser Lys Leu Asp Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Trp Gln Gly Thr His Phe Pro Arg Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr Ala Ser Val Val Cys Leu Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys Val Gln Trp Lys Val Asp Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu Ser Val Thr Glu Gln Asp Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser Thr Leu Thr Leu Ser Lys Ala Asp Tyr Glu Lys His Lys Val Tyr Ala Cys Glu Val Thr His Gln Gly Leu Ser Ser Pro Val Thr Lys Ser Phe Asn Arg Gly Glu Cys (SEQ ID NO: 6)

[0150] Humanized 3D6 Heavy Chain

Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Gly Ser Gly Phe Thr Phe Ser Asn Tyr Gly Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala Ser Ile Arg Ser Gly Gly Gly Arg Thr Tyr Tyr Ser Asp Asn Val Lys Gly Arg Phe Thr Ile Ser Arg Glu Asn Ala Lys Asn Ser Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Val Arg Tyr Asp His Tyr Ser Gly Ser Ser Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val Asp Lys Lys Val Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly

Pro Ser Val Phe Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys (SEQ ID NO: 7).

[0151] A version of humanized 10D5 antibody comprising a light chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 8 and a heavy chain having a mature variable region having the amino acid sequence designated SEQ ID NO: 9 is shown below.

[0152] Humanized 10D5 Light Chain Variable Region

Asp Val Leu Met Thr Gln Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln Asn Ile Ile His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Lys Lys Val Glu Ala Glu Asp Leu Gly Ile Tyr Tyr Cys Phe Gln Gly Ser His Val Pro Leu Thr Phe Gly Ala Gly Thr Lys Leu Glu Leu Glu (SEQ ID NO: 8)

[0153] Humanized 10D5 Heavy Chain Variable Region

Gln Ala Thr Leu Lys Glu Ser Gly Pro Gly Ile Leu Gln Ser Ser Gln Thr Leu Ser Leu Thr Cys Ser Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Gly Val Ser Trp Ile Arg Gln Pro Ser Gly Lys Gly Leu Glu Trp Leu Ala His Ile Tyr Trp Asp Asp Asp Lys Arg Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Arg Lys Gln Val Phe Leu Lys Ile Thr Ser Val Asp Pro Ala Asp Thr Ala Thr Tyr Tyr Cys Val Arg Arg Pro Ile Thr Pro Val Leu Val Asp Ala Met Asp Tyr Trp Gly Gln Gly Thr Ser Val Thr Val Ser Ser (SEQ ID NO: 9)

[0154] 12A11 or a chimeric or humanized or nanobody form thereof is a preferred antibody. The 12A11 antibody or a variant thereof, is described in US 20050118651, US 20060198851, WO 04/108895, and WO 06/066089, all of which are incorporated by reference in their entirety herein for all purposes.

[0155] 12A11 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 3-7. A cell line producing the 12A11 monoclonal antibody was deposited at the ATCC (American Type Culture Collection, 10801 University Boulevard, Manassas, VA 20110-2209) on December 12, 2005 and assigned ATCC accession number PTA-7271.

[0156] A preferred version of the humanized 12A11 antibody is version 1 comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 11. Version 1 of humanized 12A11 is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0157] Humanized 12A11 Light Chain

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Ile Val His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Gln Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Phe Gln Ser Ser His Val Pro Leu Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys (SEQ ID NO: 10)

[0158] Humanized 12A11 Heavy Chain Variable Region (version 1)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 11)

[0159] A second version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 12 (version 2) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0160] Humanized 12A11 Heavy Chain Variable Region (version 2)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 12)

[0161] A third version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 13 (version 2.1) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0162] Humanized 12A11 Heavy Chain Variable Region (version 2.1)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Asn Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 13)

[0163] A fourth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 14 (version 3) is described in WO 02/088306 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0164] Humanized 12A11 Heavy Chain Variable Region (version 3)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 14)

[0165] A fifth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 15 (version 4.1) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

Humanized 12A11 Heavy Chain Variable Region (version 4.1)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg

Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 15)

[0166] A sixth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 16 (version 4.2) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0167] Humanized 12A11 Heavy Chain Variable Region (version 4.2)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 16)

[0168] An seventh version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 17 (version 4.3) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0169] Humanized 12A11 Heavy Chain Variable Region (version 4.3)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 17)

[0170] A eighth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 18 (version 4.4) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0171] Humanized 12A11 Heavy Chain Variable Region (version 4.4)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 18)

[0172] A ninth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 19 (version 5.1) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0173] Humanized 12A11 Heavy Chain Variable Region (version 5.1)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 19)

[0174] A tenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 20 (version 5.2) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0175] Humanized 12A11 Heavy Chain Variable Region (version 5.2)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg

Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 20)

[0176] An eleventh version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 21 (version 5.3) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0177] Humanized 12A11 Heavy Chain Variable Region (version 5.3)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser Val (SEQ ID NO: 21)

[0178] A twelfth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 22 (version 5.4) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0179] Humanized 12A11 Heavy Chain Variable Region (version 5.4)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser Val (SEQ ID NO: 22)

[0180] A thirteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 23 (version 5.5) is described in US

20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0181] Humanized 12A11 Heavy Chain Variable Region (version 5.5)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 23)

[0182] A fourteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 24 (version 5.6) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0183] Humanized 12A11 Heavy Chain Variable Region (version 5.6)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 24)

[0184] A fifteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 25 (version 6.1) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0185] Humanized 12A11 Heavy Chain Variable Region (version 6.1)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 25)

[0186] A sixteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 26 (version 6.2) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0187] Humanized 12A11 Heavy Chain Variable Region (version 6.2)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 26)

[0188] A seventeenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 27 (version 6.3) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0189] Humanized 12A11 Heavy Chain Variable Region (version 6.3)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg

Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 27)

[0190] A eighteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 28 (version 6.4) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0191] Humanized 12A11 Heavy Chain Variable Region (version 6.4)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Phe Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 28)

[0192] A nineteenth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 29 (version 7) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0193] Humanized 12A11 Heavy Chain Variable Region (version 7)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Thr Leu Ser Thr Ser Gly Met Ser Val Gly Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 29)

[0194] A twentieth version of the humanized 12A11 antibody comprising a light chain having the amino acid sequence designated SEQ ID NO: 10 and a heavy chain having the amino acid sequence designated SEQ ID NO: 30 (version 8) is described in US 20050118651 A1 published on June 2, 2005, which is incorporated herein by reference for all purposes.

[0195] Humanized 12A11 Heavy Chain Variable Region (version 8)

Gln Val Gln Leu Val Glu Ser Gly Gly Gly Val Val Gln Pro Gly Arg Ser Leu Arg Leu Ser Cys Ala Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Ser Val Gly Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Asn Ser Lys Asn Thr Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg Arg Thr Thr Thr Ala Asp Tyr Phe Ala Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 30)

[0196] Other exemplary antibodies include 12B4 antibody or variant thereof, as described in US 20040082762A1 and WO 03/077858. 12B4 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 3-7. The light (SEQ ID NO: 31) and heavy chain (SEQ ID NO: 32) of 12B4 have the following variable regions (not including signal sequences).

Asp Val Leu Met Thr Gln Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln Asn Ile Val His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Leu Gly Val Tyr Tyr Cys Phe Gln Gly Ser His Val Pro Leu Thr Phe Gly Ala Gly Thr Lys Leu Glu Leu Lys (Seq ID NO: 31)

Gln Val Thr Leu Lys Glu Ser Gly Pro Gly Ile Leu Gln Pro Ser Gln Thr Leu Ser Leu Thr Cys Ser Phe Ser Gly Phe Ser Leu Ser Thr Asn Gly Met Gly Val Ser Trp Ile Arg Gln Pro Ser Gly Lys Gly Leu Glu Trp Leu Ala His Ile Tyr Trp Asp Glu Asp Lys Arg Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Asn Asn Gln Val Phe Leu Lys Ile Thr Asn Val Asp Thr Ala Asp Thr Ala Thr Tyr Tyr Cys Ala Arg Arg Arg Ile Ile Tyr Asp Val Glu Asp Tyr Phe Asp Tyr Trp Gly Gln Gly Thr Thr Leu Thr Val Ser Ser (SEQ ID NO: 32)

[0197] Other exemplary antibodies are 6C6 antibody, or a variant thereof, as described in a US 20060165682 and WO 06/06604. 6C6 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 3-7. A cell line producing the antibody 6C6 was deposited on November 1, 2005, with the ATCC under the terms of the Budapest Treaty and assigned accession number PTA-7200.

[0198] Other exemplary antibodies are 2H3 antibody and variants thereof as described in US 20060257396. 2H3 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 2-7. A cell line producing the antibody 2H3 was deposited on December 13, 2005, with the ATCC under the terms of the Budapest Treaty and assigned accession number PTA-7267.

[0199] Other exemplary antibodies include 3A3 and variants thereof as described in US 20060257396. 3A3 is a mAb that specifically binds to an N-terminal epitope located in the human β-amyloid peptide, specifically, residues 3-7. A cell line producing the antibody 3A3 was deposited on December 13, 2005, with the ATCC under the terms of the Budapest Treaty and assigned accession number PTA-7269.

[0200] Other exemplary antibodies are 2B1, 1C2 or 9G8. Cell lines producing the antibodies 2B1, 1C2 and 9G8 were deposited on November 1, 2005, with the ATCC under the terms of the Budapest Treaty and were assigned accession numbers PTA-7202, PTA-7199 and PTA-7201, respectively.

[0201] Another exemplary antibody is a humanized 266 antibody or variant thereof. The 266 antibody binds to an epitope between residues 13-28 of Aβ. A cell line producing the antibody 266 antibody was deposited on July 20, 2004 with the ATCC under the terms of the Budapest Treaty and assigned accession numer PTA-6123. Humanized forms of the 266 antibody are described in US 20040265308, US 20040241164, WO 03/016467, and US 7,195,761. The light (SEQ ID NO: 33) and heavy chain (SEQ ID NO: 34) of the 266 antibody have the following variable region sequences (not including signal sequences).

> Asp Xaa Val Met Thr Gln Xaa Pro Leu Ser Leu Pro Val Xaa Xaa Gly Gln Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Xaa Tyr Ser Asp Gly Asn Ala Tyr Leu His Trp Phe Leu Gln Lys Pro Gly Gln Ser Pro Xaa Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Xaa Gly Val Tyr Tyr Cys Ser Gln Ser Thr His Val Pro Trp Thr Phe Gly Xaa Gly Thr Xaa Xaa Glu Ile Lys Arg (SEQ ID NO: 33)

wherein: Xaa at position 2 is Val or Ile; Xaa at position 7 is Ser or Thr; Xaa at position 14 is Thr or Ser; Xaa at position 15 is Leu or Pro; Xaa at position 30 is Ile or Val; Xaa at position 50 is Arg, Gln, or Lys; Xaa at position 88 is Val or Leu; Xaa at position 105 is Gln or Gly; Xaa at position 108 is Lys or Arg; and Xaa at position 109 is Val or Leu; and

Xaa Val Gln Leu Val Glu Xaa Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Arg Tyr Ser Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Xaa Leu Val Ala Gln Ile Asn Ser Val Gly Asn Ser Thr Tyr Tyr Pro Asp Xaa Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Xaa Xaa Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Xaa Asp Thr Ala Val Tyr Tyr Cys Ala Ser Gly Asp Tyr Trp Gly Gln Gly Thr Xaa Val Thr Val Ser Ser (SEQ ID NO: 34)

wherein: Xaa at position 1 is Glu or Gln; Xaa at position 7 is Ser or Leu; Xaa at position 46 is Glu, Val, Asp, or Ser; Xaa at position 63 is Thr or Ser; Xaa at position 75 is Ala, Ser, Val or Thr; Xaa at position 76 is Lys or Arg; Xaa at position 89 is Glu or Asp; and Xaa at position 107 is Leu or Thr.

[0202] An exemplary humanized 266 antibody comprises the following light chain (SEQ ID NO: 35) and heavy chain (SEQ ID NO: 36) sequences (not including signal sequences).

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Leu Gly Gln Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Ile Tyr Ser Asp Gly Asn Ala Tyr Leu His Trp Phe Leu Gln Lys Pro Gly Gln Ser Pro Arg Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Ser Gln Ser Thr His Val Pro Trp Thr Phe Gly Gln Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr Ala Ser Val Val Cys Leu Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys Val Gln Trp Lys Val Asp Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu Ser Val Thr Glu Gln Asp Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser Thr Leu Thr Leu Ser Lys Ala Asp Tyr Glu Lys His Lys Val Tyr Ala Cys Glu Val Thr His Gln Gly Leu Ser Ser Pro Val Thr Lys Ser Phe Asn Arg Gly Glu Cys (SEQ ID NO: 35)

Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Arg Tyr Ser Met Ser Trp Val Ary Gln Ala Pro Gly Lys Gly Leu Glu Leu Val Ala Gln Ile Asn Ser Val Gly Asn Ser Thr Tyr Tyr Pro Asp Thr Val Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ala Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Ser Gly Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu Thr

Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu Tyr Ser Leu Ser Ser Va Val Thr Val Pro Ser Ser Ser Leu Gly Thr Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val Asp Lys Lys Val Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala Lys Gly Gln Pro Ary Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys (SEQ ID NO: 36)

[0203] The antibody can also be 15C11 or a humanized form thereof (*see* US 20060165682), which specifically binds to an epitope within Aβ15-24.

[0204] The antibody can also be a humanized form of 20C2 or a variant thereof. Such antibodies are described, *e.g.*, in US 2007081998. The core linear epitope for 20C2 corresponds to amino acid residues 3-8 of Aβ1-42, with a conformational epitope that is dependent upon elements from within residues 17-42 of Aβ. The light (SEQ ID NO: 37) and heavy chain (SEQ ID NO: 38) of humanized 20C2 antibody (version 1) have the following variable region sequences (not including signal sequences).

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Ile Leu His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Gln Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Phe Gln Gly Ser Leu Val Pro Leu Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys (SEQ ID NO: 37)

Gln Val Thr Leu Lys Glu Ser Gly Pro Ala Leu Val Lys Pro Thr Gln Thr Leu Thr Leu Thr Cys Thr Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Gly Val Gly Trp Ile Arg Gln Pro Pro Gly Lys Ala Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Ser

Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Gln Val Val Leu Thr Met Thr Asn Met Asp Pro Val Asp Thr Ala Thr Tyr Tyr Cys Ala Arg Arg Gln Leu Gly Leu Arg Ser Ile Asp Ala Met Asp Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser (SEQ ID NO: 38)

[0205] An additional humanized 20C2 antibody (version 2) comprises the light chain variable region sequence of SEQ ID NO: 37 and the heavy chain variable region sequence of SEQ ID NO: 39 (not including signal sequence).

Gln Val Thr Leu Lys Glu Ser Gly Pro Ala Leu Val Lys Pro Thr Gln Thr Leu Thr Leu Thr Cys Thr Leu Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Gly Val Gly Trp Ile Arg Gln Pro Pro Gly Lys Ala Leu Glu Trp Leu Ala His Ile Trp Trp Asp Asp Asp Lys Ser Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Asn Gln Val Val Leu Thr Met Thr Asn Met Asp Pro Val Asp Thr Ala Thr Tyr Tyr Cys Ala Arg Arg Gln Leu Gly Leu Arg Ser Ile Asp Ala Met Asp Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser (SEQ ID NO: 39)

[0206] Another antibody that can be used according to the invention is C705 or a variant thereof, which binds an epitope comprising amino acids 7-12 of the Aβ peptide, as described in WO 05/028511. The C705 antibody comprises the light chain variable region sequence of SEQ ID NO: 40 and heavy chain variable region of SEQ ID NO: 41, signal sequence underlined.

Met Lys Leu Pro Val Arg Leu Leu Val Leu Met Phe Trp Ile Pro Gly Ser Ser Ser Asp Val Met Met Thr Gln Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Met Gln Lys Pro Gly Gln Ser Pro Met Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Ser Val Glu Ala Glu Asp Leu Gly Val Phe Tyr Cys Phe Gln Gly Ser Arg Val Pro Leu Thr Phe Gly Ala Gly Thr Lys Leu Glu Leu Lys Arg (SEQ ID NO: 40)

Met Asp Arg Leu Thr Ser Ser Phe Leu Leu Leu Ile Val Pro Ala Tyr Val Leu Ser Gln Val Thr Leu Lys Glu Ser Gly Pro Gly Ile Leu Gln Pro Ser Gln Thr Leu Ser Leu Thr Cys Ser Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Gly Val Ser Trp Ile Arg Gln Pro Ser Gly Lys Gly Leu Glu Trp Leu Ala His Ile Tyr Trp Asp Asp Asp Lys Arg Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Arg Asn Gln Val Phe Leu Lys Ile Thr Ser Val Asp Thr Thr Asp Thr Ala Thr Tyr Tyr Cys Thr Arg Ser Ser

Gly Ser Ile Val Ile Ala Thr Gly Phe Ala Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ala (SEQ ID NO: 41)

[0207] Another antibody that can be used according to the invention is C706 or a variant thereof, which binds to an epitope comprising amino acids 6-11 of the Aβ peptide, as described in WO 05/028511. The C706 antibody comprises the light chain variable region sequence of SEQ ID NO: 42, and the the heavy chain variable region sequence of SEQ ID NO: 43. Signal sequences are underlined.

Met Asp Phe Gln Val Gln Ile Phe Ser Phe Leu Leu Ile Ser Ala Ser Val Ile Ile Ser Arg Gly Gln Ile Val Leu Thr Gln Ser Pro Ala Ile Met Ser Ala Ser Pro Gly Glu Lys Val Thr Met Thr Cys Ser Ala Ser Ser Ser Val Ser Tyr Met His Trp Tyr Gln Gln Lys Ser Gly Thr Ser Pro Lys Arg Trp Ile Tyr Asp Ser Ser Arg Leu Ala Ser Gly Val Pro Ser Arg Phe Ser Gly Gly Gly Ser Gly Thr Ser Tyr Ser Pro Thr Ile Ser Asn Met Glu Ala Glu Asp Ala Ala Thr Tyr Phe Cys Gln Asn Trp Arg Ser Ser Pro Thr Phe Gly Ala Gly Thr Lys Leu Glu Leu Lys Arg (SEQ ID NO: 42)

Met Glu Trp Thr Trp Val Phe Leu Phe Leu Leu Ser Val Thr Ala Gly Val His Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Glu Leu Met Lys Pro Gly Ala Ser Val Lys Ile Ser Cys Lys Ala Thr Gly Tyr Thr Phe Ser Thr Ser Trp Ile Glu Trp Ile Lys Gln Arg Pro Gly His Gly Leu Glu Trp Ile Gly Glu Val Leu Pro Gly Ser Gly Lys Ser Asn His Asn Ala Asn Phe Lys Gly Arg Ala Thr Phe Thr Ala Asp Thr Ala Ser Asn Thr Ala Tyr Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Tyr Cys Ala Arg Glu Gly Ser Asn Asn Asn Ala Leu Ala Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ala (SEQ ID NO: 43)

[0208] Other antibodies that can be used according to the invention include humanized 2286 antibodies and variants thereof. These antibodies recognize an epitope comprising amino acids 28-40 of the Aβ peptide, as described in US 20070160616. A humanized 2286 antibody (version 1) comprises the light chain variable region of SEQ ID NO: 44 and the heavy chain variable region of SEQ ID NO: 45 (not including signal sequences).

DIQMTQSPSSLSASVGDRVTITCSASQGISNYLNWYQQKPGKAPKLLIYYTSSL HSGVPSRFSGSGSGTDFTFTISSLQPEDIATYYCQQYRKLPYTFGGGTKVEIKR (SEQ ID NO: 44)

EVQLVESGGGLVQPGGSLRLSCAASGFDFSRYWMNWVRQAPGKGLEWVSEI NPDSSTINYTPSLKDRFTISRDNAKNTLYLQMNSLRAEDTAVYYCARQMGYW GQGTTLTVSS (SEQ ID NO: 45)

[0209] Another version of humanized 2286 comprises the light chain variable region of SEQ ID NO: 44 and the heavy chain variable region of SEQ ID NO: 46 (not including signal sequences).

QVQLQESGPGLVKPSETLSLTCTVSGFDFSRYWMNWIRQPPGKGLEWIGEINP DSSTINYTPSLKDRVTISKDTSKNQFSLKLSSVTAADTAVYYCARQMGYWGQ GTLVTVSS (SEQ ID NO: 46)

[0210] Additional antibodies that can be used according to the invention are a fourth version of humanized 3D6 and a second version of humanized 10D5, as disclosed in US 7,318,923 and 7,320,790, respectively. These antibodies bind to the N-terminus of the Aβ peptide, as explained above. The humanized 3D6 (version 4) comprises the light chain variable region sequence of SEQ ID NO: 71 and the heavy chain variable region sequence of SEQ ID NO: 72.

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Leu GlyGln Pro Ala Ser Ile Ser Cys Lys Ser Ser Gln Ser Leu Leu Asp Ser Asp Gly Lys Thr Tyr Leu Asn Trp Leu Gln Gln Arg Pro Gly Gln Ser Pro Arg Arg Leu Ile Tyr Leu Val Ser Lys Leu Asp Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Trp Gln Gly Thr His Phe Pro Arg Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys Arg (SEQ ID NO: 71)

Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Gly Ser Gly Phe Thr Phe Ser Asn Tyr Gly Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ala Ser Ile Arg Ser Gly Gly Gly Arg Thr Tyr Tyr Ser Asp Asn Val Lys Gly Arg Phe Thr Ile Ser Arg Glu Asn Ala Lys Asn Ser Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Val Arg Tyr Asp His Tyr Ser Gly Ser Ser Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser (SEQ ID NO: 72)

[0211] The humanized 10D5 antibody (version 2) comprises the light chain variable region sequence of SEQ ID NO: 73 and the heavy chain variable region sequence of SEQ ID NO: 74.

Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro Val Thr Leu Gly Gln Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Asn Ile Ile His Ser Asn Gly Asn Thr Tyr Leu Glu Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Arg Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Val Gly Val Tyr Tyr Cys Phe Gln Gly Ser His Val Pro Leu Thr Phe Gly Gly Gly Thr Lys Val Glu Ile Lys Arg (SEQ ID NO: 73)

Gln Val Thr Leu Lys Glu Ser Gly Pro Val Leu Val Lys Pro Thr Glu Thr Leu Thr Leu Thr Cys Thr Phe Ser Gly Phe Ser Leu Ser Thr Ser Gly Met Gly Val Ser Trp Ile Arg Gln Pro Pro Gly Lys Ala Leu Glu Trp Leu Ala His Ile Tyr Trp Asp Asp Asp Lys Arg Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile Ser Lys Asp Thr Ser Lys Ser Gln Val Val Leu Thr Met Thr Asn Met Asp Pro Val Asp Thr Ala Thr Tyr Tyr Cys Val Arg Arg Pro Ile Thr Pro Val Leu Val Asp Ala Met Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser (SEQ ID NO: 74)

[0212] Another exemplary antibody is humanized 2E7, as disclosed in WO 07/113172. The 2E7 antibody binds residues 1-12 of Aβ peptide, but not 2-13, or longer variants of the peptide. Humanized 2E7 antibody (version 1) comprises light chain variable region sequence of SEQ ID NO: 75 and heavy chain variable region sequence of SEQ ID NO: 76.

DIVMTQSPLSLPVTPGEPASISCRVSQSLLHSNGYTYLHWYLQKPGQSPQLLIY KVSNRFSGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCSQTRHVPYTFGGGT KVEIK (SEQ ID NO: 75)

EVQLVESGGGLVQPGGSLRLSCAASGFTFSDNGMAWVRQAPGKGLEWVSFIS NLAYSIDYADTVTGRFTISRDNAKNSLYLQMNSLRAEDTAVYYCVSGTWFA YWGQGTLVTVSS (SEQ ID NO: 76)

[0213] A second version of humanized 2E7 antibody comprises the light chain variable region of SEQ ID NO: 75 and the heavy chain variable region sequence of SEQ ID NO: 77 (*see, e.g.*, WO 07/113172).

EVQLVESGGGLVQPGGSLRLSCAVSGFTFSDNGMAWVRQAPGKGLEWVSFIS NLAYSIDYADTVTGRFTISRDNAKNSLYLQMNSLRAEDTAVYYCVSGTWFA YWGQGTLVTVSS (SEQ ID NO: 77)

[0214] Humanized 2E7 antibody (version 3) comprises the light chain variable region sequence of SEQ ID NO: 75 and the heavy chain variable region sequence of SEQ ID NO: 78 (*see, e.g.*, WO 07/113172).

EVQLVESGGGLVQPGGSLRLSCAASGFTFSDNGMAWVRQAPGKGLEWISFIS NLAYSIDYADTVTGRFTISRDNAKNSLYLQMNSLRAEDTAVYYCVSGTWFA YWGQGTLVTVSS (SEQ ID NO: 78)

[0215] An additional antibody that can be used according to the invention includes humanized 9TL antibody (ATCC accession numbers PTA-6124 and PTA-6125), as described in WO 06/036291. The heavy and light chain variable regions, without signal sequences, are shown as SEQ ID NO: 79 and SEQ ID NO: 80, respectively.

QVQLVQSGAEVKKPGASVKVSCKASGYYTEAYYIHWVRQAPGQGLEWMGR IDPATGNTKYAPRLQDRVTMTRDTSTSTVYMELSSLRSEDTAVYYCASLYSLP VYWGQGTTVTVSS (SEQ ID NO: 79)

DVVMTQSPLSLPVTLGQPASISCKSSQSLLYSDAKTYLNWFQQRPGQSPRRLI YQISRLDPGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCLQGTHYPVLFGQG TRLEIKRT (SEQ ID NO: 80)

[0216] Humanized versions of the 6G antibody can also be used according to the invention. The heavy and light chain variable regions, without signal sequences, are shown as SEQ ID NOs:81 and 82, respectively.

QVQLVQSGAEVKKPGASVKVSCKASGYTFTTYAIHWVRQAPGQGLEWMGF TSPYSGVSNYNQKFKGRVTMTRDTSTSTVYMELSSLRSEDTAVYYCARFDNY DRGYVRDYWGQGTLV (SEQ ID NO: 81)

DIVMTQSPDSLAVSLGERATINCRASESVDNDRISFLNWYQQKPGQPPKLLIY AATKQGTGVPDRFSGSGSGTDFTLTISSLQAEDVAVYYCQQSKEFPWSFGGG TKVEIKRTV (SEQ ID NO: 82)

[0217] Additional antibodies that can be used according to the invention are humanized versions of the 2.1 antibody, as described in WO 06/081171. These antibodies rely on the CDRs of the murine 2.1 antibody and substitute residues from the human VKII A19/ JK4 light chain variable framework region. The heavy chain variable framework region used for substitution is roughly based on VH 2-70. An exemplary humaninzed 2.1 antibody

comprises the heavy and light chain variable regions, without signal sequences, shown as SEQ ID NOs: 83 and 84, respectively.

QVTLKESGPALVKPTQTLTLTCTFSGFSLRTSGMGVGWIRQPPGKALEWLAHI WWDDDKSYNPSLKSQLTISKDTSKNQVVLTMTNMDPVDTATYYCARRNYY YDDYFAYWGQGTLVTVSS (SEQ ID NO: 83)

DVLMTQSPLSLPVTLGQPASISCRSSQSIVHSNGNTYLEWYLQRPGQSPKLLIY KVSNRFSGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPLTFGAGT KLEIK (SEQ ID NO: 84)

[0218] Other antibodies that can be used according to the invention include CW1181 and CW1185 antibodies. These antibodies specifically bind to two regions of the Aβ peptide, as described in WO 03/070760 and US 20050196399. The first region comprises AEFRHDSGY (SEQ ID NO: 85) or a fragment thereof (*e.g.*, AEFRHD (SEQ ID NO: 86), or EFRHDSG (SEQ ID NO: 87), EFRHD (SEQ ID NO: 88)) and second region comprises the amino acid sequence YEVHHQKLVFFAEDVG (SEQ ID NO: 89) or a fragment thereof (*e.g.*, VFFA (SEQ ID NO: 90), or QKLFFAEDV (SEQ ID NO: 91)).

[0219] An additional antibody that can be used according to the invention is the monoclonal NAB61 antibody. NAB61 binds Aβ1-11, but does not bind to full length APP or C99, as disclosed in WO 07/062088. Similary, the monoclonal 82E1 antibody can be used according to the invention. 82E1 binds the N-terminus of the Aβ peptide, but not full length APP, as disclosed in US 20080025988.

[0220] Other antibodies of the invention are anti-ADDL antibodies. Such antibodies have been generated and selected for the ability to bind ADDLs specifically, without binding to Aβ monomer or amyloid fibrils. *See e.g.*, WO 04/031400.

[0221] Other antibodies that can be used include (i) the catalytic antibody ABP 102 (Abzyme, from Abiogen Pharma); (ii) ACI-01 Ab7 C2 (AC Immune Genentech); (iii) AZD-3102 (AstraZeneca/Dyax); (iv) IVIg (Gammagard S/D Immune Globulin Intravenous (Human), from Baxter Bioscience); (v) BAN 2401 (BioArctic Neuroscience AB/ Eisai Co. Ltd.; (vi) R1450 (Hoffman-La Roche/MorphoSys); (vii) LY2062430 (Eli Lilly); (viii) h3D6 (Eli Lilly); (ix) ACU-5A5 (α ADDL mAb from Merck/Acumen); α-amyloidspheroid (ASPD) antibody (Mitsubishi Pharma Corp.); (xi) the antibody derived from PBMCs of an AN1792 patient (Neurimmune Therapeutics AG); (xii) BC05 (Takeda); (xiii) the CEN701-

CEN706 antibodies (Centocor/Johnson & Johnson); and (xiv) PF-04360365 (also called RN-1219 (h2286), from Pfizer/Rinat Neurosciences). Each of these antibodies can be used according to any of the methods of the invention.

[0222] The ABP 102 antibody cleaves aggregated Aβ as described, *e.g.*, in US 6,387,674 and WO 99/06536. The ACI-01 Ab7 C2 antibody binds the Aβ peptide between residues 10-20 and is described in US 20070166311. The IVIg Gammagard SD Immune Globulin antibody is described, *e.g.*, on the Baxter Bioscience website at Baxter.com. The BAN 2401 antibody is a humanized antibody that binds Aβ protofibrils, and is described, *e.g.*, in WO 05/123775. The human R-1450 HuCAL antibody has a dual 266/3D6 epitope. The humanized LY2062430 antibody (IgG) binds the Aβ peptide between residues 16-23, and is described, *e.g.*, in US Patent No. 7,195,761. The humanized h3D6 antibody binds the Aβ peptide at residues 1-5, and is described, *e.g.*, in US Patent No. 7,318,923. The BC05 antibody binds a C terminal Aβ epitope, as described by Asami-Odaka *et al.* (2005) *Neurodegenerative Diseases* 2:36-43. The CEN701- CEN706 antibodies are described, *e.g.*, in WO 05/028511. The humanized PF-04360365 antibody binds the Aβ peptide between residues 28-40 and is described, *e.g.*, in WO 04/032868.

[0223] Any of the antibodies or antibody fragments described herein can be designed or prepared using standard methods, as disclosed, *e.g.*, in US 20040038304, US 20070020685, US 200601660184, US 20060134098, US 20050255552, US 20050130266, US 2004025363, US 20040038317, US 20030157579, and US 7,335,478.

[0224] Any of the antibodies described above can be produced with different isotypes or mutant isotypes to control the extent of binding to different Fcγ receptors. Antibodies lacking an Fc region (*e.g.*, Fab fragments) lack binding to Fcγ receptors. Selection of isotype also affects binding to Fcγ receptors. The respective affinities of various human IgG isotypes for the three Fcγ receptors, FcγRI, FcγRII, and FcγRIII, have been determined. (*See* Ravetch & Kinet, Annu. Rev. Immunol. 9, 457 (1991)). FcγRI is a high affinity receptor that binds to IgGs in monomeric form, and the latter two are low affinity receptors that bind IgGs only in multimeric form. In general, both IgG1 and IgG3 have significant binding activity to all three receptors, IgG4 to FcγRI, and IgG2 to only one type of FcγRII called IIa_{LR} (*see* Parren *et al.*, J. Immunol. 148, 695 (1992). Therefore, human isotype IgG1 is usually selected for stronger binding to Fcγ receptors is desired, and IgG2 is usually selected for weaker binding.

[0225] Mutations on, adjacent, or close to sites in the hinge link region (*e.g.*, replacing residues 234, 235, 236 and/or 237 with another residue) in all of the isotypes reduce affinity for Fcγ receptors, particularly FcγRI receptor (*see*, *e.g.*, US 6,624,821). Optionally, positions 234, 236 and/or 237 are substituted with alanine and position 235 with glutamine. (*See*, *e.g.*, US 5,624,821.) Position 236 is missing in the human IgG2 isotype. Exemplary segments of amino acids for positions 234, 235 and 237 for human IgG2 are Ala Ala Gly, Val Ala Ala, Ala Ala Ala, Val Glu Ala, and Ala Glu Ala. A preferred combination of mutants is L234A, L235A, and G237A for human isotype IgG1. A particular preferred antibody is bapineuzumab having human isotype IgG and these three mutations of the Fc region. Other substitutions that decrease binding to Fcγ receptors are an E233P mutation (particularly in mouse IgG1) and D265A (particularly in mouse IgG2a). Other examples of mutations and combinations of mutations reducing Fc and/or C1q binding are described in the Examples (E318A/K320A/R322A (particularly in mouse IgG1), L235A/E318A/K320A/K322A (particularly in mouse IgG2a). Similarly, residue 241 (Ser) in human IgG4 can be replaced, *e.g.*, with proline to disrupt Fc binding.

[0226] Additional mutations can be made to the constant region to modulate effector activity. For example, mutations can be made to the IgG2a constant region at A330S, P331S, or both. For IgG4, mutations can be made at E233P, F234V and L235A, with G236 deleted, or any combination thereof. IgG4 can also have one or both of the following mutations S228P and L235E. The use of disrupted constant region sequences to modulate effector function is further described, *e.g.*, in WO 06/118,959 and WO 06/036291.

[0227] Additional mutations can be made to the constant region of human IgG to modulate effector activity (*see*, *e.g.*, WO 06/03291). These include the following substitutions: (i) A327G, A330S, P331S; (ii) E233P, L234V, L235A, G236 deleted; (iii) E233P, L234V, L235A; (iv) E233P, L234V, L235A, G236 deleted, A327G, A330S, P331S; and (v) E233P, L234V, L235A, A327G, A330S, P331S to human IgG1.

[0228] The affinity of an antibody for the FcR can be altered by mutating certain residues of the heavy chain constant region. For example, disruption of the glycosylation site of human IgG1 can reduce FcR binding, and thus effector function, of the antibody (*see*, *e.g.*, WO 06/036291). The tripeptide sequences NXS, NXT, and NXC, where X is any amino acid other than proline, are the enzymatic recognition sites for glycosylation of the N residue. Disruption of any of the tripeptide amino acids, particularly in the CH2 region of IgG, will

prevent glycosylation at that site. For example, mutation of N297 of human IgG1 prevents glycosylation and reduces FcR binding to the antibody.

[0229] The sequences of several exemplary humanized 3D6 antibodies and their components parts are shown below. Human constant regions show allotypic variation and isoallallotypic variation between different individuals, that is, the constant regions can differ in different individuals at one or more polymorphic positions. Isoallotypes differ from allotypes in that sera recognizing an isoallotype binds to a non-polymorphic region of a one or more other isotypes. The allotype of the IgG1 constant region shown below is 3D6 (AAB-001) is G1mz which has Glu at position 356 and Met at position 358. The allotype of the kappa constant region shown below is Km3, which has an Ala at position 153 and a Val at position 191. A different allotye Km(1) has Val and Leu at positions 153 and 191 respectively. Allotypic variants are reviewed by J Immunogen 3: 357-362 (1976) and Loghem,. Monogr Allergy 19: 40-51 (1986) . Other allotypic and isoallotypic variants of the illustrated constant regions are included. Also included are constant regions having any permutation of residues occupying polymorphic positions in natural allotypes. Examples of other heavy chain IgG1 allotypes include: G1m(f), G1m(a) and G1m(x). G1m(f) differs from G1m(z) in that it has an Arg instead of a Lys at position 214. G1m(a) has amino acids Arg, Asp, Glu, Leu at positions 355-358.

[0230] Humanized 3D6 Full Length Light Chain (signal sequence underlined) (bapineuzumab and AAB-003)

MDMRVPAQLLGLLMLWVSGSSGDVVMTQSPLSLPVTPGEPASISCKSSQSLL
DSDGKTYLNWLLQKPGQSPQRLIYLVSKLDSGVPDRFSGSGSGTDFTLKISRV
EAEDVGVYYCWQGTHFPRTFGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTAS
VVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSK
ADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO: 47)

[0231] Humanized 3D6 Full Length Light Chain, Not Including Signal Sequence (bapineuzumab and AAB-003)

DVVMTQSPLSLPVTPGEPASISCKSSQSLLDSDGKTYLNWLLQKPGQSPQRLI
YLVSKLDSGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPRTFGQ
GTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDN
ALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSP
VTKSFNRGEC (SEQ ID NO: 48)

[0232] DNA encoding humanized 3D6 Light Chain Coding Sequence (signal sequence underlined) (bapineuzumab and AAB-003)

ATGGACATGCGCGTGCCCGCCCAGCTGCTGGGCCTGCTGATGCTGTGGGT
GTCCGGCTCCTCCGGCGACGTGGTGATGACCCAGTCCCCCCTGTCCCTGCC
CGTGACCCCCGGCGAGCCCGCCTCCATCTCCTGCAAGTCCTCCCAGTCCCT
GCTGGACTCCGACGGCAAGACCTACCTGAACTGGCTGCTGCAGAAGCCCG
GCCAGTCCCCCCAGCGCCTGATCTACCTGGTGTCCAAGCTGGACTCCGGC
GTGCCCGACCGCTTCTCCGGCTCCGGCTCCGGCACCGACTTCACCCTGAAG
ATCTCCCGCGTGGAGGCCGAGGACGTGGGCGTGTACTACTGCTGGCAGGG
CACCCACTTCCCCCCGCACCTTCGGCCAGGGCACCAAGGTGGAGATCAAGC
GTACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGT
TGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCA
GAGAGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAA
CTCCCAGGAGAGTGTCACAGAGCAGGACAGCAAGGACAGCACCTACAGC
CTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAGAAACACAAAG
TCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAG
AGCTTCAACAGGGGAGAGTGTTAG (SEQ ID NO: 49)

[0233] Human Heavy Chain Constant Region, IgG1 Isotype, L234A/G237A

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKT
HTCPPCPAPEALGAPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN
WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNK
ALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEA
LHNHYTQKSLSLSPGK (SEQ ID NO: 50)

The C-terminal K residue can be absent, as indicated below.

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKT
HTCPPCPAPEALGAPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN
WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNK
ALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVE

WESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEA
LHNHYTQKSLSLSPG (SEQ ID NO: 51).

[0234] Humanized 3D6 Full Length Heavy Chain (IgG1 Isotype, L234A/G237A) including signal sequence (underlined)

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKS
TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVV
TVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEALGAPS
VFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKP
REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP
REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPP
VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
(SEQ ID NO: 52)

The C-terminal K residue can be absent, as indicated below.

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKS
TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVV
TVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEALGAPS
VFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKP
REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP
REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPP
VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPG
(SEQ ID NO: 53).

[0235] Humanized 3D6 Full Length Heavy Chain Not Including Signal Sequence (IgG1 Isotype, L234A/G237A)

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS

NTKVDKKVEPKSCDKTHTCPPCPAPEALGAPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 54)

The C-terminal K residue can be absent, as indicated below.

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS
NTKVDKKVEPKSCDKTHTCPPCPAPEALGAPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPG (SEQ ID NO: 55).

[0236] Human Heavy Chain Constant Region, IgG4 Isotype, S241P (Kabat numbering); S228P (EU numbering)

ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPC
PPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYV
DGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPS
SIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWES
NGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHN
HYTQKSLSLSLGK (SEQ ID NO: 56)

The C-terminal K residue can be absent, as indicated below.

ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPC
PPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYV
DGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPS
SIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWES

NGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHN
HYTQKSLSLSLG (SEQ ID NO: 57)

[0237] Humanized 3D6 Full Length Heavy Chain (IgG4 Isotype, S241P), Including Signal Sequence (underlined)

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPCSRS
TSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT
VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFP
PKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQ
FNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQ
VYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLD
SDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGK (SEQ
ID NO: 58)

The C-terminal K residue can be absent, as indicated below.

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPCSRS
TSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVT
VPSSSLGTKTYTCNVDHKPSNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFP
PKPKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQ
FNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQ
VYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLD
SDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLSLG (SEQ
ID NO: 59).

[0238] Humanized 3D6 Heavy Chain, Not Including Signal Sequence (IgG4 Isotype, S241P)

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPS

NTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVV
DVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWL
NGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTC
LVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQE
GNVFSCSVMHEALHNHYTQKSLSLSLGK (SEQ ID NO: 60)

The C-terminal K residue can be absent, as indicated below.

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTKTYTCNVDHKPS
NTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVV
DVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWL
NGKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTC
LVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSRLTVDKSRWQE
GNVFSCSVMHEALHNHYTQKSLSLSLG (SEQ ID NO: 61).

[0239] Human Heavy Chain Constant Region, IgG1 Isotype (AAB-003), L234A/L235A/G237A

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKT
HTCPPCPAPEAAGAPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN
WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNK
ALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVE
WESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEA
LHNHYTQKSLSLSPGK (SEQ ID NO: 62)

The C-terminal K residue can be absent, as indicated below.

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTF
PAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKT
HTCPPCPAPEAAGAPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFN
WYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNK
ALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVE

WESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEA
LHNHYTQKSLSLSPG (SEQ ID NO: 63).

[0240] Humanized 3D6 Full Length Heavy Chain Including Signal Sequence (IgG1 isotype, L234A/L235A/G237A): AAB-003

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKS
TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVV
TVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEAAGAPS
VFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKP
REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP
REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPP
VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
(SEQ ID NO: 64)

The C-terminal K residue can be absent, as indicated below.

MEFGLSWLFLVAILKGVQCEVQLLESGGGLVQPGGSLRLSCAASGFTFSNYG
MSWVRQAPGKGLEWVASIRSGGGRTYYSDNVKGRFTISRDNSKNTLYLQMN
SLRAEDTAVYYCVRYDHYSGSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKS
TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVV
TVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEAAGAPS
VFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKP
REEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQP
REPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPP
VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPG
(SEQ ID NO: 65).

[0241] Humanized 3D6 Heavy Chain, Not Including Signal Sequence (IgG1 isotype, L234A/L235A/G237A): AAB-003

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS

NTKVDKKVEPKSCDKTHTCPPCPAPEAAGAPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 66)

The C-terminal K residue can be absent, as indicated below.

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS
NTKVDKKVEPKSCDKTHTCPPCPAPEAAGAPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPG (SEQ ID NO: 67).

[0242] DNA encoding humanized 3D6 Heavy Chain Coding Region including Signal Sequence (underlined) (IgG1 isotype, L234A/L235A/G237A): AAB-003

ATGGAGTTTGGGCTGAGCTGGCTTTTTCTTGTGGCTATTTTAAAAGGTGTC
CAGTGTGAGGTGCAGCTGCTGGAGTCCGGCGGCGGCCTGGTGCAGCCCGG
CGGCTCCCTGCGCCTGTCCTGCGCCGCCTCCGGCTTCACCTTCTCCAACTA
CGGCATGTCCTGGGTGCGCCAGGCCCCCGGCAAGGGCCTGGAGTGGGTGG
CCTCCATCCGCTCCGGCGGCGGCCGCACCTACTACTCCGACAACGTGAAG
GGCCGCTTCACCATCTCCCGCGACAACTCCAAGAACACCCTGTACCTGCA
GATGAACTCCCTGCGCGCCGAGGACACCGCCGTGTACTACTGCGTGCGCT
ACGACCACTACTCCGGCTCCTCCGACTACTGGGGCCAGGGCACCCTGGTG
ACCGTGTCCTCCGCGTCGACCAAGGGCCCATCGGTCTTCCCCCTGGCACCC
TCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCCTGGGCTGCCTGGTCAA
GGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGCGCCCTGA
CCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACT
CCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACCCAGACC
TACATCTGCAACGTGAATCACAAGCCCAGCAACACCAAGGTGGACAAGA
AAGTTGAGCCCAAATCTTGTGACAAAACTCACACATGCCCACCGTGCCCA

GCACCTGAAGCCGCTGGGGCACCGTCAGTCTTCCTCTTCCCCCCAAAACCC
AAGGACACCCTCATGATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGT
GGACGTGAGCCACGAAGACCCTGAGGTCAAGTTCAACTGGTACGTGGACG
GCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTACAA
CAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGC
TGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCCAGCC
CCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAACCAC
AGGTGTACACCCTGCCCCCATCCCGGGAGGAGATGACCAAGAACCAGGTC
AGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGA
GTGGGAGAGCAATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCC
GTGCTGGACTCCGACGGCTCCTTCTTCCTCTATAGCAAGCTCACCGTGGAC
AAGAGCAGGTGGCAGCAGGGGAACGTCTTCTCATGCTCCGTGATGCATGA
GGCTCTGCACAACCACTACACGCAGAAGAGCCTCTCCCTGTCCCCGGGTA
AATGA (SEQ ID NO: 68)

[0243] Full-length heavy chain of bapineuzumab, not including signal sequence, IgG1 isotype, no Fc mutations

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS
NTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTC
VVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ
DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQV
SLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR
WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 69)

[0244] The C-terminal K residue can be absent, as indicated below.

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIR
SGGGRTYYSDNVKGRFTISRDNSKNTLYLQMNSLRAEDTAVYYCVRYDHYS
GSSDYWGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPV
TVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPS
NTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTC
VVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ

DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQV
SLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR
WQQGNVFSCSVMHEALHNHYTQKSLSLSPG (SEQ ID NO: 70)

[0245] In some antibodies, positions 234, 235, and 237 of a human IgG heavy chain constant region can be AAA respectively, LLA respectively, LAG respectively, ALG respectively, AAG respectively, ALA respectively, or LAA respectively. As shown above, AAB-003 is an L234A, L235A, and G237A variant of bapineuzumab (*i.e.*, having identical amino acid sequences to bapineuzumab except for the L234A, L235A, and G237A mutations, alanine (A) being the variant amino acid). Like bapineuzumab, AAB-003 has a full-length human kappa light chain constant region and a full-length human IgG1 heavy chain constant region (in either bapineuzumab or AAB-003, a C-terminal lysine residue is sometimes cleaved intracellularly and is sometimes missing from the final product).

[0246] Although the three mutations in AAB-003 are close to the hinge region rather than the complement binding region, AAB-003 has reduced binding to both Fcγ receptors and to C1q, relative to bapineuzumab. Thus, the AAB-003 antibody has reduced capacity to induce both phagocytosis and the complement cascade. Furthermore, AAB-003 displays less binding to human FcγRII than an otherwise identical antibody with fewer than the three mutations present in AAB-003 (*e.g.*, one with substitutions at residues 234 and 237), indicating that all three mutations in the AAB-003 Fc region contribute to reducing effector function. Mutation of the heavy chain constant region to reduce interaction with Fcγ receptor(s) and or C1q can reduce microhemorrhaging in a mouse model without eliminating useful activities. Microhemorraghing in mice is one factor that may contribute to vasogenic edema occurring in humans. Antibodies bearing such mutations retain the ability to inhibit cognitive decline as well as ability to clear amyloid deposits.

[0247] Similarly heavy chain constant region mutants can also be combined with the variable region sequences described above, *e.g.*, for humanized 12A11 and 12B4 antibodies. The following table shows exemplary combinations of heavy chain variable regions and heavy chain constant regions with mutation(s) for antibodies described above. The heavy chains shown in the table for a particular antibody e.g., 12A11, can be paired with any of the light chain variable regions described above for that antibody linked to a light chain constant region (e.g., a human kappa light chain constant region as follows:

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNS
QESVTEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRG
EC (SEQ ID NO: 85)

or an allotype or isoallotype thereof.

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
10D5 (version 1)	9	50
	9	51
	9	56
	9	57
	9	62
	9	63
12B4	32	50
	32	51
	32	56
	32	57
	32	62
	32	63
12A11 (version 1)	11	50
	11	51
	11	56
	11	57
	11	62
	11	63
12A11 (version 2)	12	50
	12	51
	12	56
	12	57
	12	62
	12	63
12A11 (version 2.1)	13	50
	13	51
	13	56
	13	57

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	13	62
	13	63
12A11 (version 3)	14	50
	14	51
	14	56
	14	57
	14	62
	14	63
12A11 (version 4.1)	15	50
	15	51
	15	56
	15	57
	15	62
	15	63
12A11 (version 4.2)	16	50
	16	51
	16	56
	16	57
	16	62
	16	63
12A11 (version 4.3)	17	50
	17	51
	17	56
	17	57
	17	62
	17	63
12A11 (version 4.4)	18	50
	18	51
	18	56
	18	57
	18	62
	18	63
12A11 (version 5.1)	19	50

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	19	51
	19	56
	19	57
	19	62
	19	63
12A11 (version 5.2)	20	50
	20	51
	20	56
	20	57
	20	62
	20	63
12A11 (version 5.3)	21	50
	21	51
	21	56
	21	57
	21	62
	21	63
12A11 (version 5.4)	22	50
	22	51
	22	56
	22	57
	22	62
	22	63
12A11 (version 5.5)	23	50
	23	51
	23	56
	23	57
	23	62
	23	63
12A11 (version 5.6)	24	50
	24	51
	24	56
	24	57

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	24	62
	24	63
12A11 (version 6.1)	25	50
	25	51
	25	56
	25	57
	25	62
	25	63
12A11 (version 6.2)	26	50
	26	51
	26	56
	26	57
	26	62
	26	63
12A11 (version 6.3)	27	50
	27	51
	27	56
	27	57
	27	62
	27	63
12A11 (version 6.4)	28	50
	28	51
	28	56
	28	57
	28	62
	28	63
12A11 (version 7)	29	50
	29	51
	29	56
	29	57
	29	62
	29	63
12A11 (version 8)	30	50

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	30	51
	30	56
	30	57
	30	62
	30	63
12B4	32	50
	32	51
	32	56
	32	57
	32	62
	32	63
266	34	50
	34	51
	34	56
	34	57
	34	62
	34	63
20C2 (version 1)	38	50
	38	51
	38	56
	38	57
	38	62
	38	63
20C2 (version 2)	39	50
	39	51
	39	56
	39	57
	39	62
	39	63
C705	41	50
	41	51
	41	56
	41	57

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	41	62
	41	63
C706	43	50
	43	51
	43	56
	43	57
	43	62
	43	63
2286 (version 1)	45	50
	45	51
	45	56
	45	57
	45	62
	45	63
2286 (version 2)	46	50
	46	51
	46	56
	46	57
	46	62
	46	63
3D6 (version 4)	72	50
	72	51
	72	56
	72	57
	72	62
	72	63
10D6 (version 2)	74	50
	74	51
	74	56
	74	57
	74	62
	74	63
2E7 (version 1)	76	50

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	76	51
	76	56
	76	57
	76	62
	76	63
2E7 (version 2)	77	50
	77	51
	77	56
	77	57
	77	62
	77	63
2E7 (version 3)	78	50
	78	51
	78	56
	78	57
	78	62
	78	63
9TL	79	50
	79	51
	79	56
	79	57
	79	62
	79	63
6G	81	50
	81	51
	81	56
	81	57
	81	62
	81	63
2.1	82	50
	82	51
	82	56
	82	57

Table 1
Correlation of Full Length Heavy Chain SEQ ID NOS with Respective Variable and Constant Region SEQ ID NOS

Antibody	Heavy Chain Variable region	Heavy Chain Constant region
	82	62
	82	63

[0248] Amino acids in the constant region are numbered by alignment with the human antibody EU (*see* Cunningham *et al.*, *J. Biol. Chem.*, 9, 3161 (1970)). That is, the heavy and light chains of an antibody are aligned with the heavy and light chains of EU to maximize amino acid sequence identity and each amino acid in the antibody is assigned the same number as the corresponding amino acid in EU. The EU numbering system is conventional (*see* generally, Kabat *et al.*, *Sequences of Protein of Immunological Interest,* NIH Publication No. 91-3242, US Department of Health and Human Services (1991)).

[0249] The affinity of an antibody for complement component Clq can be altered by mutating at least one of the amino acid residues 318, 320, and 322 of the heavy chain to a residue having a different side chain. Other suitable alterations for altering, *e.g.*, reducing or abolishing, specific Clq-binding to an antibody include changing any one of residues 318 (Glu), 320 (Lys) and 322 (Lys), to Ala. Clq binding activity can be abolished by replacing any one of the three specified residues with a residue having an inappropriate functionality on its side chain. It is not necessary to replace the ionic residues only with Ala to abolish Clq binding. It is also possible to use other alkyl-substituted non-ionic residues, such as Gly, Ile, Leu, or Val, or such aromatic non-polar residues as Phe, Tyr, Trp and Pro in place of any one of the three residues in order to abolish Clq binding. In addition, it is also be possible to use such polar non-ionic residues as Ser, Thr, Cys, and Met in place of residues 320 and 322, but not 318, to abolish Clq binding activity. Replacement of the 318 (Glu) residue by a polar residue may modify but not abolish Clq binding activity. Replacing residue 297 (Asn) with Ala results in removal of lytic activity while only slightly reducing (about three fold weaker) affinity for Clq. This alteration destroys the glycosylation site and the presence of carbohydrate that is required for complement activation. Any other substitution at this site also destroys the glycosylation site.

[0250] Additional mutations that can affect C1q binding to the constant region of human IgG1 include those described, *e.g.*, in WO 06/036291. In this case, at least one of the

following substitutions can be made to reduce C1q binding: D270A, K322A, P329A, and P311S. Each of these mutations, including those at residues 297, 318, and 320 can be made individually or in combination.

[0251] Antibodies with heavy chain constant region mutations that reduce binding to Fcγ receptor(s) and/or C1q can be used in any of the methods of the invention. Preferably, such antibodies have reduced binding relative to an otherwise identical antibody lacking the mutation of at least 50% to at least one Fcγ receptor and/or to C1q.

B. Aβ Fragments

[0252] Numerous fragments of Aβ have been now been described in the scientific and patent literature as agents for active immunotherapy (*see, e.g.*, US 6,750,324, US 20040213800; US 20070134762). In general, fragments including an epitope within residues 1-11 of Aβ induce antibodies that bind Fcγ receptors and induce a clearing response against amyloid deposits, whereas fragments lacking an epitope within residues 1-11 of Aβ induce antibodies that bind preferentially or exclusively to soluble forms of Aβ rather than plaques and induces little if any clearing response against amyloid deposits.

[0253] Preferred fragment for inducing antibodies that bind to amyloid deposits and induce a clearing response are N-terminal fragments beginning at residues 1-3 of Aβ and ending at residues 7-11 of Aβ. Exemplary N-terminal fragments include Aβ1-5, 1-6, 1-7, 1-10, 3-7, 1-3, and 1-4 with 1-7 being particularly preferred. A class of exemplary fragments includes fragments begining at a residue between 1-3 (inclusive) and ending at a residue between 7-11 (inclusive).

[0254] Preferred fragments for inducing antibodies to soluble Aβ, which induce little, if any, clearing response against amyloid deposits include Aβ15-21, Aβ16-22, Aβ17-23, Aβ18-24, Aβ19-25, Aβ15-22, Aβ16-23, Aβ17-24, Aβ18-25, Aβ15-23, Aβ16-24, Aβ17-25, Aβ18-26, Aβ15-24, Aβ16-25, and Aβ15-25. Aβ16-23 is particularly preferred meaning s a fragment including residues 16-23 of Aβ and lacking other residues of Aβ. Also preferred are C-terminal fragments of Aβ42 or 43 of 5-10 and preferably 7-10 contiguous amino acids. Analogous C-terminal fragments of Aβ40, or 39 can also be used. These fragments can generate an antibody response that includes end-specific antibodies. Fragments preferably lack T-cell epitopes that would induce T-cells against Aβ. Generally, T-cell epitopes are greater than 10 contiguous amino acids. Therefore, preferred fragments of Aβ are of size 5-10 or preferably 7-10 contiguous amino acids; *i.e.*, sufficient length to generate an antibody

response without generating a T-cell response. Absence of T-cell epitopes is preferred because these epitopes are not needed for immunogenic activity of fragments, and may cause an undesired inflammatory response in a subset of patients.

[0255] Agents to induce antibodies to Aβ that can be used in the methods of the invention also include (i) ACI-24 (AC Immune); (ii) Affitopes AD02 and AD02 (Affiris GmbH); (iii) Arctic Immunotherapeutic KLVFFAGDV (SEQ ID NO: 92) (BioArctic Neuroscience/ Eisai); (iv) Aβ1-15-K-K-Aβ1-15 (Brigham & Women's Hospital); (v) β-Vax™ and Recall-Vax™ (Intellect Neurosciences); (vi) K6-Aβ1-30 (Intellect Neurosciences/ NYU); (vii) V-950 (Merck); (viii) CAD106 (Novartis/ Cytos); (ix) Aβ DCtag™ nanoparticle adjuvant (Prana Biotechnology/ PRIMABioMed); (x) PX106 (also 2Aβ1-11-PADRE, from Pharmexa/ Lundbeck); (xi) Aβ4-10 conjugated to a T cell epitope (U. Toronto); and (xii) p3102 and p3075 (United Biomedical).

[0256] ACI-24 is an Aβ1-15 liposome construct with Aβ1-15-K-K-16C palmitic acid inserted into a liposomal bilayer. These compounds are described in US 2004/0242845, WO 05/081872, US 2007/0281006, and US 2006/0073158. Affitopes AD01 and AD02 are mimotopes from the N-terminus of Aβ, as described in WO 06/005707. The Arctic Immunotherapeutic is derived from Aβ22 of E692G, as described in US 20020162129 and US 20070248606. Aβ1-15-K-K-Aβ1-15 represents two linked N-terminal Aβ fragments, as described in WO 05/012330 and WO 02/0123553. β-Vax™, Recall-Vax™ and K6-Aβ1-30 are Aβ fragments linked to a T cell epitope, as described in WO 01/42306. V-950 is an 8-mer Aβ peptide linked to a multivalent linear peptide with at least one spacer and a multivalent branched multiple antigen peptide, as described in WO 06/121656. CAD106 is a Qβ carrier (an RNA VLP) linked to an N-terminal Aβ peptide, as described in WO 04/016282. The Aβ DCtag™ nanoparticle adjuvant is described, *e.g.*, in WO 02/00245. PX106 is a Aβ1-11 peptide linked to a T cell epitope called a "pan DR epitope peptide (PADRE)," as described in US 7,135,181. p3102 and p3075 are Aβ1-14 peptides linked by a spacer to a T cell epitope (*e.g.*, measles epitope), as described in US 20030068325 US 20040247612, US 6,906,169, and WO 02/096350.

[0257] Fragments are usually natural Aβ peptides but can include unnatural amino acids or modifications of N or C terminal amino acids at a one, two, five, ten or even all positions. For example, the natural aspartic acid residue at position 1 and/or 7 of Aβ can be replaced with iso-aspartic acid. Examples of unnatural amino acids are D, alpha, alpha-disubstituted

amino acids, N-alkyl amino acids, lactic acid, 4-hydroxyproline, γ-carboxyglutamate, epsilon-N,N,N-trimethyllysine, epsilon-N-acetyllysine, O-phosphoserine, N-acetylserine, N-formylmethionine, 3-methylhistidine, 5-hydroxylysine, omega-N-methylarginine, β-alanine, ornithine, norleucine, norvaline, hydroxproline, thyroxine, γ-amino butyric acid, homoserine, citrulline, and isoaspartic acid. Some therapeutic agents of the invention are all-D peptides, *e.g.*, all-D Aβ or all-D Aβ fragment, and all-D peptide analogs. Fragments can be screened for prophylactic or therapeutic efficacy in transgenic animal models in comparison with untreated or placebo controls.

[0258] Fragments are typically conjugated to carrier molecules, which provide a T-cell epitope, and thus promote an immune response against the fragment conjugated to the carrier. A single agent can be linked to a single carrier, multiple copies of an agent can be linked to multiple copies of a carrier, which are in turn linked to each other, multiple copies of an agent can be linked to a single copy of a carrier, or a single copy of an agent can be linked to multiple copies of a carrier, or different carriers. Suitable carriers include serum albumins, keyhole limpet hemocyanin, immunoglobulin molecules, thyroglobulin, ovalbumin, tetanus toxoid, or a toxoid from other pathogenic bacteria, such as diphtheria (*e.g.*, CRM197), *E. coli,* cholera, or *H. pylori*, or an attenuated toxin derivative. T cell epitopes are also suitable carrier molecules. Some conjugates can be formed by linking agents of the invention to an immunostimulatory polymer molecule (*e.g.*, tripalmitoyl-S-glycerine cysteine (Pam_3Cys), mannan (a mannose polymer), or glucan (a β 1→2 polymer)), cytokines (*e.g.*, IL-1, IL-1 alpha and β peptides, IL-2, γ-INF, IL-10, GM-CSF), and chemokines (*e.g.*, MIP1-α and β, and RANTES). Immunogenic agents can also be linked to peptides that enhance transport across tissues, as described in O'Mahony, WO 97/17613 and WO 97/17614. Immunogens may be linked to the carries with or with out spacers amino acids (*e.g.*, gly-gly).

[0259] Additional carriers include virus-like particles. Virus-like particles (VLPs), also called pseudovirions or virus-derived particles, represent subunit structures composed of multiple copies of a viral capsid and/or envelope protein capable of self assembly into VLPs of defined spherical symmetry *in vivo*. (Powilleit, *et al.*, (2007) *PLoS ONE* 2(5):e415.) These particles have been found to be useful as antigen delivery systems. VLPs can be produced and readily purified in large quantities and due to their particulate nature and high molecular weights. VLPs induce an immune response without additional application of an adjuvant. (Ulrich *et al.*, (1996) *Intervirology* 39:126-132.) Exemplary chimeric particles useful as VLP antigen delivery systems include those based on hepatitis B virus, human

immunodeficiency virus (HIV), yeast retrotransposon Ty, yeast totivirus L-A, parvovirus, influenza virus, Norwalk virus, rotavirus, adeno-associated virus, bluetongue virus, hepatitis A virus, human papillomavirus, measles virus, polyoma virus and RNA phage virus, as well as those based on various retroviruses and lentiviruses. For review, *see* Lechner, *et al.* (2002) *Intervirology* 45:212-217.

[0260] The core protein of hepatitis B virus (HBcAg) is a common VLP used for carrying foreign antigens (*see* Koletzki *et* al., (1997) *J Gen Vir* 78:2049-2053). Briefly, HBcAg can be used as a core to construct VLPs that present extended foreign protein segments. The method employs a construct having a linker sequence between the a C-terminally truncated HBcAg and a foreign protein sequence that contains a stop codon. Truncated HBcAg/foreign protein chimera is expressed utilizing a read through mechanism based on the opal TGA-Trp mutation for expression in an *E. coli* suppressor strain. The method described by Koletzki *et al.* allows for incorporation of long foreign protein sequences into VLPs, allowing for a greater variety of antigens to be carried by the VLP.

[0261] The HIV virus Gag protein can be used as an antigen carrier system (*see* Griffiths *et al.*, (1993) *J Virol.* 67(6):3191-3198). Griffiths utilized the V3 loop of HIV, which is the principle neutralizing determinant of the HIV envelope. The Gag:V3 fusion proteins assembled *in vivo* into hybrid Gag particles, designated virus-derived particles (VDPs). The VDPs induce both humoral and cellular responses. As the V3 loop contains a CTL epitope, immunization with Gag:V3 induces a CTL response to the V3 protein portion of the VLP.

[0262] A hybrid HIV:Ty VLP can also be used (*see* Adams *et al.*, (1987) *Nature* 329(3):68-70). The HIV:Ty VLP employs the p1 protein of the yeast transposon Ty. The first 381 amino acids of p1 are sufficient for VLP formation. The HIV:Ty fusion proteins are capable of assembling into VLPs *in vivo*, as well as inducing an immune response to the HIV antigen carried by the VLP. VLPs using the Ty p1 protein can also contain p1 fused to the whole of an alpha2-interferon, the product of the bovine papilloma virus E1 and E2 genes, and a portion of an influenza hemagglutinin. Each of these Ty fusions formed VLPs and were capable of inducing production of antisera to the non-Ty VLP component.

[0263] VLPs can also be designed from variants of the yeast totivirus L-A (*see* Powilleit *et al.* (2007) *PLOS One* 2(5):e415). The Pol gene of the L-A virus can be replaced with an appropriate antigen to induce a specific immune response, demonstrating that yeast VLPs are effective antigen carriers.

[0264] Recombinant, nonreplicative parvovirus-like particles can also be used as antigen carriers. (Sedlik, *et al.* (1997) PNAS 94:7503-7508.) These particles allow the carried antigens into the cytosol so they enter the class I-restricted immunological pathway, thus stimulating cytotoxic T-lymphocyte (CTL) mediated responses. Sedlik specifically used PPV:VLP, which contained the VP2 capsid protein of the parvovirus and residues 118-132 from the lymphocytic choriomeningitis virus (LCMV) was inserted into the VP2 capsid protein. The PPV:VLP containing LCMV was capable of inducing an immune response to LCMV and elicited immunological protection against lethal viral doses in pre-immunized mice.

[0265] VLPs can also comprise replication incompetent influenza that lack the influenza NS2 gene, the gene essential for viral replication. (Watanabe, *et al.* (1996) *J Virol.* 76(2):767-773.) These VLPs infect mammalian cells and allow expression of foreign proteins.

[0266] Norwalk virus (NV)-based VLPs can also be used as vehicles for immunogen delivery. (Ball, *et al.* (1999) *Gastroenterology* 117:40-48.) The NV genome has three open reading frames (ORFs 1-3). Recombinant baculovirus expression of ORFs 2 and 3 allows for spontaneous assembly of high yields of recombinant Norwalk virus (rNV) VLPs.

[0267] Some conjugates can be formed by linking agents of the invention to at least one T cell epitope. Some T cell epitopes are promiscuous whereas other T cell epitopes are universal. Promiscuous T cell epitopes are capable of enhancing the induction of T cell immunity in a wide variety of subjects displaying various HLA types. In contrast to promiscuous T cell epitopes, universal T cell epitopes are capable of enhancing the induction of T cell immunity in a large percentage, *e.g.*, at least 75%, of subjects displaying various HLA molecules encoded by different HLA-DR alleles.

[0268] A large number of naturally occurring T-cell epitopes exist, such as, tetanus toxoid (*e.g.*, the P2 and P30 epitopes), Hepatitis B surface antigen, pertussis, toxoid, measles virus F protein, *Chlamydia trachomatis* major outer membrane protein, diphtheria toxoid, *Plasmodium falciparum* circumsporozoite T, *Plasmodium falciparum* CS antigen, *Schistosoma mansoni* triose phosphate isomerase, *Escherichia coli* TraT, and Influenza virus hemagglutinin (HA). The immunogenic peptides of the invention can also be conjugated to the T-cell epitopes described in Sinigaglia F. *et al.*, *Nature*, 336:778-780 (1988); Chicz R.M. *et al.*, *J. Exp. Med.*, 178:27-47 (1993); Hammer J. *et al.*, *Cell* 74:197-203 (1993); Falk K. *et*

al., *Immunogenetics*, 39:230-242 (1994); WO 98/23635; and, Southwood S. *et al. J. Immunology*, 160:3363-3373 (1998).

[0269] Carriers also include virus-like particles (*see* US 20040141984).

[0270] Fragments are often administered with pharmaceutically acceptable adjuvants. The adjuvant increases the titer of induced antibodies and/or the binding affinity of induced antibodies relative to the situation if the peptide were used alone. A variety of adjuvants can be used in combination with an immunogenic fragment of Aβ, to elicit an immune response. Preferred adjuvants augment the intrinsic response to an immunogen without causing conformational changes in the immunogen that affect the qualitative form of the response. Preferred adjuvants include aluminum hydroxide and aluminum phosphate, 3 De-O-acylated monophosphoryl lipid A (MPL™) (*see* GB 2220211 (RIBI ImmunoChem Research Inc., Hamilton, Montana, now part of Corixa). Stimulon™ QS-21 is a triterpene glycoside or saponin isolated from the bark of the Quillaja Saponaria Molina tree found in South America (*see* Kensil *et al.*, in *Vaccine Design: The Subunit and Adjuvant Approach* (eds. Powell & Newman, Plenum Press, NY, 1995); US 5,057,540), (Aquila BioPharmaceuticals, Framingham, MA; now Antigenics, Inc., New York, NY). Other adjuvants are oil in water emulsions (such as squalene or peanut oil), optionally in combination with immune stimulants, such as monophosphoryl lipid A (*see* Stoute *et al.*, *N. Engl. J. Med.* 336, 86-91 (1997)), pluronic polymers, and killed mycobacteria. Another adjuvant is CpG (WO 98/40100). Adjuvants can be administered as a component of a therapeutic composition with an active agent or can be administered separately, before, concurrently with, or after administration of the therapeutic agent.

[0271] A preferred class of adjuvants is aluminum salts (alum), such as alum hydroxide, alum phosphate, alum sulfate. Such adjuvants can be used with or without other specific immunostimulating agents such as MPL or 3-DMP, QS-21, polymeric or monomeric amino acids such as polyglutamic acid or polylysine. Another class of adjuvants is oil-in-water emulsion formulations. Such adjuvants can be used with or without other specific immunostimulating agents such as muramyl peptides (*e.g.*, N-acetylmuramyl-L-threonyl-D-isoglutamine (thr-MDP), N-acetyl-normuramyl-L-alanyl-D-isoglutamine (nor-MDP), N-acetylmuramyl-L-alanyl-D-isoglutaminyl-L-alanine-2-(1'-2'dipalmitoyl-sn-glycero-3-hydroxyphosphoryloxy)-ethylamine (MTP-PE), N-acetylglucsaminyl-N-acetylmuramyl-L-Al-D-isoglu-L-Ala-dipalmitoxy propylamide (DTP-DPP) theramideTM), or other bacterial

cell wall components. Oil-in-water emulsions include (a) MF59 (WO 90/14837), containing 5% Squalene, 0.5% Tween 80, and 0.5% Span 85 (optionally containing various amounts of MTP-PE) formulated into submicron particles using a microfluidizer such as Model 110Y microfluidizer (Microfluidics, Newton MA), (b) SAF, containing 10% Squalene, 0.4% Tween 80, 5% pluronic-blocked polymer L121, and thr-MDP, either microfluidized into a submicron emulsion or vortexed to generate a larger particle size emulsion, and (c) Ribi™ adjuvant system (RAS), (Ribi ImmunoChem, Hamilton, MT) containing 2% squalene, 0.2% Tween 80, and one or more bacterial cell wall components from the group consisting of monophosphorylipid A (MPL), trehalose dimycolate (TDM), and cell wall skeleton (CWS), preferably MPL + CWS (Detox™).

[0272] Another class of preferred adjuvants is saponin adjuvants, such as Stimulon™ (QS-21, Aquila, Framingham, MA) or particles generated therefrom such as ISCOMs (immunostimulating complexes) and ISCOMATRIX. Other adjuvants include RC-529, GM-CSF and Complete Freund's Adjuvant (CFA) and Incomplete Freund's Adjuvant (IFA). Other adjuvants include cytokines, such as interleukins (*e.g.*, IL-1 α and β peptides,, IL-2, IL-4, IL-6, IL-12, IL13, and IL-15), macrophage colony stimulating factor (M-CSF), granulocyte-macrophage colony stimulating factor (GM-CSF), tumor necrosis factor (TNF), chemokines, such as MIP1α and β and RANTES. Another class of adjuvants is glycolipid analogues including N-glycosylamides, N-glycosylureas and N-glycosylcarbamates, each of which is substituted in the sugar residue by an amino acid, as immuno-modulators or adjuvants (*see* US 4,855,283). Heat shock proteins, *e.g.*, HSP70 and HSP90, may also be used as adjuvants.

[0273] An adjuvant can be administered with an immunogen as a single composition, or can be administered before, concurrent with or after administration of the immunogen. Immunogen and adjuvant can be packaged and supplied in the same vial or can be packaged in separate vials and mixed before use. Immunogen and adjuvant are typically packaged with a label indicating the intended therapeutic application. If immunogen and adjuvant are packaged separately, the packaging typically includes instructions for mixing before use. The choice of an adjuvant and/or carrier depends on the stability of the immunogenic formulation containing the adjuvant, the route of administration, the dosing schedule, the efficacy of the adjuvant for the species being vaccinated, and, in humans, a pharmaceutically acceptable adjuvant is one that has been approved or is approvable for human administration by

pertinent regulatory bodies. For example, Complete Freund's adjuvant is not suitable for human administration. Alum, MPL and QS-21 are preferred. Optionally, two or more different adjuvants can be used simultaneously. Preferred combinations include alum with MPL, alum with QS-21, MPL with QS-21, MPL or RC-529 with GM-CSF, and alum, QS-21 and MPL together. Also, Incomplete Freund's adjuvant can be used (Chang *et al.*, *Advanced Drug Delivery Reviews* 32, 173-186 (1998)), optionally in combination with any of alum, QS-21, and MPL and all combinations thereof.

V. Patients Amenable to Treatment

[0274] The present regimes are useful for treatment of any disease characterized by amyloid deposits of Aβ in the brain. As well as Alzheimer's disease, such diseases include Down's syndrome, Parkinson's disease, mild-cognitive impairment, and vascular amyloid disease. Patients amenable to treatment include individuals at risk of disease but not showing symptoms, as well as patients presently showing symptoms. In the case of Alzheimer's disease, virtually anyone is at risk of suffering from Alzheimer's disease if he or she lives long enough. Therefore, the present methods can be administered prophylactically to the general population without the need for any assessment of the risk of the subject patient. The present methods can also be useful for individuals who have a known genetic risk of Alzheimer's disease. Such individuals include those having relatives who have experienced this disease, and those whose risk is determined by analysis of genetic or biochemical markers. Genetic markers of risk toward Alzheimer's disease include mutations in the APP gene, particularly mutations at position 717 and positions 670 and 671 referred to as the Hardy and Swedish mutations respectively (*see* Hardy, *supra*). Other markers of risk are mutations in the presenilin genes, PS1 and PS2, and ApoE4, family history of AD, hypercholesterolemia or atherosclerosis. Individuals presently suffering from Alzheimer's disease can be recognized from characteristic dementia, as well as the presence of risk factors described above. In addition, a number of diagnostic tests are available for identifying individuals who have AD. These include measurement of CSF tau and Aβ42 levels. Elevated tau and decreased Aβ42 levels signify the presence of AD. Individuals suffering from Alzheimer's disease can also be diagnosed by ADRDA criteria as discussed in the Examples section.

[0275] In asymptomatic patients, treatment can begin at any age (*e.g.*, 10, 20, 30). Usually, however, it is not necessary to begin treatment until a patient reaches 40, 50, 60 or 70 years

of age. Treatment typically entails multiple dosages over a period of time. Treatment can be monitored by assaying antibody levels over time. If the response falls, a booster dosage is indicated. In the case of potential Down's syndrome patients, treatment can begin antenatally by administering therapeutic agent to the mother or shortly after birth.

[0276] Patients amenable to treatment include patients 50 to 87 years of age, patients suffering from mild to moderate Alzheimer's disease, patients having an MMSE score of 14-26, patients having a diagnosis of probable Alzheimer's disease based on Neurological and Communicative Disorders and Stroke-Alzheimer's disease Related Disorders (NINCDS-ADRDA) criteria, and/or patients having an Rosen Modified Hachinski Ischemic score less than or equal to 4. Patients with MRI an scan consistent with the diagnosis of Alzheimer's disease, *i.e.*, that there are no other abnormalities present on the MRI that could be attributed to other diseases, *e.g.* stroke, traumatic brain injury, arachnoid cysts, tumors, etc are also amendable to treatment.

VI. Treatment Regimes

[0277] In prophylactic applications, agents or pharmaceutical compositions or medicaments containing the same are administered to a patient susceptible to, or otherwise at risk of, Alzheimer's disease in an amount sufficient to eliminate or reduce the risk, lessen the severity, or delay the outset of the disease, including biochemical, histologic and/or behavioral symptoms of the disease, its complications and intermediate pathological phenotypes presenting during development of the disease. In therapeutic applications, compositions or medicaments are administered to a patient suspected of, or already suffering from such a disease in an amount sufficient to cure, or at least partially arrest, the symptoms of the disease (biochemical, histologic and/or behavioral), including its complications and intermediate pathological phenotypes in development of the disease.

[0278] Effective doses of the compositions of the present invention, for the treatment of the above described conditions vary depending upon many different factors, including means of administration, target site, physiological state of the patient, whether the patient is human or an animal, other medications administered, and whether treatment is prophylactic or therapeutic.

[0279] Optionally, antibodies are administered to achieve a mean serum concentration of administered antibody of 0.1-60, 0.4-20, or 1-15 μg/ml in a patient. These ranges bracket the demonstrated effective concentrations in mice and humans allowing some margin for error in

measurement and individual patient variation. The serum concentration can be determined by actual measurement or predicted from standard pharmacokinetics (*e.g.*, WinNonline Version 4.0.1 (Pharsight Corporation, Cary, USA)) based on the amount of antibody administered, frequency of administration, route of administration and antibody half-life.

[0280] The mean antibody concentration in the serum is optionally within a range of 1-10, 1-5 or 2-4 μg/ml. It is also optional to maintain a maximum serum concentration of the antibody in the patient less than about 28 μg antibody/ml serum for maximizing therapeutic benefit relative to the occurrence of possible side effects, particularly vascular edema. A preferred maximum serum concentration is within a range of about 4-28 μg antibody/ml serum. The combination of maximum serum less than about 28 μg antibody/ml serum and an mean serum concentration of the antibody in the patient is below about 7 μg antibody/ml serum is particularly beneficial. Optionally, the mean concentration is within a range of about 2-7 μg antibody/ml serum.

[0281] The concentration of Aβ in plasma following antibody administration changes roughly in parallel with changes of antibody serum concentration. In other words, plasma concentration of Aβ is highest after a dose of antibody and then declines as the concentration of antibody declines between doses. The dose and regime of antibody administration can be varied to obtain a desired level of Aβ in plasma. In such methods, the mean plasma concentration of antibody can be at least 450 pg/ml or for example, within a range of 600-30000 pg/ml or 700-2000 pg/ml or 800-1000 pg/ml.

[0282] The preferred dosage ranges for antibodies are from about 0.01 to 5 mg/kg, and more usually 0.1 to 3 mg/kg or 0.15-2 mg/kg or 0.15-1.5 mg/kg, of the host body weight. Subjects can be administered such doses daily, on alternative days, weekly, biweekly, monthly, quarterly, or according to any other schedule determined by empirical analysis. An exemplary treatment entails administration in multiple dosages over a prolonged period, for example, of at least six months. Additional exemplary treatment regimes entail administration once per every two weeks or once a month or once every 3 to 6 months.

[0283] For intravenous administration, doses of 0.1 mg/kg to 2 mg/kg , and preferably 0.5 mg/kg or 1.5 mg/kg administered intravenously quarterly are suitable. Preferred doses of antibody for monthly intravenous administration occur in the range of 0.1-1.0 mg/kg antibody or preferably 0.5-1.0 mg/kg antibody.

[0284] For more frequent dosing, *e.g.*, from weekly to monthly dosing, subcutaneous administration is preferred. Subcutaneous dosing is easier to administer and can reduce maximum serum concentrations relative to intravenous dosing. The doses used for subcutaneous dosing are usually in the range of 0.01 to 0.6 mg/kg or 0.01-0.35 mg/kg, preferably, 0.05-0.25 mg/kg. For weekly or biweekly dosing, the dose is preferably in the range of 0.015-0.2 mg/kg, or 0.05-0.15 mg/kg. For weekly dosing, the dose is preferably 0.05 to 0.07 mg/kg, *e.g.*, about 0.06 mg/kg. For biweekly dosing, the dose is preferably 0.1 to 0.15 mg/kg. For monthly dosing, the dose is preferably 0.1 to 0.3 mg/kg or about 0.2 mg/kg. Monthly dosing includes dosing by the calendar month or lunar month (*i.e.*, every four weeks). Here as elsewhere in the application, dosages expressed in mg/kg can be converted to absolute mass dosages by multiplying by the mass of a typical patient (*e.g.*, 70 or 75 kg) typically rounding to a whole number. Other regimes are described by *e.g.*, PCT/US2007/009499. The dosage and frequency can be varied within these guidelines based on the ApoE status of the patient as discussed above.

[0285] The amount of an agent for active administration varies from 1-500 μg per patient and more usually from 5-100 μg per injection for human administration. Exemplary dosages per injection are 3, 10, 30, or 90 μg for each human injection. The mass of immunogen also depends on the mass ratio of immunogenic epitope within the immunogen to the mass of immunogen as a whole. Typically, 10^{-3} to 10^{-5} micromoles of immunogenic epitope are used for each immunization of immunogen. The timing of injections can vary significantly from once a day, to once a year, to once a decade. On any given day that a dosage of immunogen is given, the dosage is greater than 1 μg/patient and usually greater than 10 μg/ patient if adjuvant is also administered, and greater than 10 μg/patient and usually greater than 100 μg/patient in the absence of adjuvant. A typical regimen consists of an immunization followed by booster injections at time intervals, such as 6 week intervals. Another regimen consists of an immunization followed by booster injections 1, 2 and 12 months later. Another regimen entails an injection every two months for life Alternatively, booster injections can be on an irregular basis as indicated by monitoring of immune response. The dosage and frequency can be varied such that antibodies induced by an active agent have mean serum concentrations within a range of 0.1-60, 0.4-20, or 1-15 or 2-7 μg/ml as in passive administration. The dosage and frequency can be varied within these guidelines based on the ApoE status of the patient as discussed above.

VII. Exemplary Regimes Depending On Carrier Status

[0286] The invention provides methods of treating non-carrier patients having Alzheimer's disease (*e.g.*, mild or moderate) in which an effective regime of an antibody that specifically binds to an N-terminal epitope of Aβ is administered to such a patient. The antibody can for example bind to an epitope within residues 1-11, 1-7, 1-5, or 3-7 of Aβ. Optionally, the antibody is bapineuzumab. The dosage of the antibody can be within a range of about 0.15 mg/kg to 2 mg/kg administered by intravenous infusion. Optionally, the dosage is about 0.5 mg/kg to about 1 mg/kg The dosage can be administered for example every 8-16 weeks, every 1-14 weeks or every 13 weeks.

[0287] The invention also provides methods of reducing cognitive decline in a non-carrier patient having been diagnosed with mild or moderate Alzheimer's disease. The method entails administering an effective regime of an antibody that specifically binds to an N-terminal epitope of Aβ to such a patient. The antibody can for example bind to an epitope within residues 1-11, 1-7, 1-5, or 3-7 of Aβ. Optionally, the antibody is bapineuzumab. The dosage of the antibody can be within a range of about 0.15 mg/kg to 2 mg/kg administered by intravenous infusion. Optionally, the dosage is about 0.5 mg/kg to about 1 mg/kg The dosage can be administered for example every 8-16 weeks, every 1-14 weeks or every 13 weeks. Cognitive decline can be measured by comparing the patient being treated with the cognitive decline in a population of control patients also of non-carrier status and having mild or moderate Alzheimer's disease (*e.g.*, a control population in a clinical trial). Cognitive ability can be measured by scales such as ADAS-COG, NTB, MMSE or CDR-SB. The rate of change in such a scale (points over time) in a patient can be compared with the mean decline in a population of control patients as described above.

[0288] The invention also provides methods of reducing brain volume decline in a non-carrier patient having been diagnosed with mild or moderate Alzheimer's disease. The method entails administering an effective regime of an antibody that specifically binds to an N-terminal epitope of Aβ to such a patient. The antibody can for example bind to an epitope within residues 1-11, 1-7, 1-5, or 3-7 of Aβ. Optionally, the antibody is bapineuzumab. The dosage of the antibody can be within a range of about 0.15 mg/kg to 2 mg/kg administered by intravenous infusion. Optionally, the dosage is about 0.5 mg/kg to about 1 mg/kg The dosage can be administered for example every 8-16 weeks, every 1-14 weeks or every 13 weeks. Brain volume can be measured by MRI. Change in brain volume in a patient can be

compared with the mean decline in brain volume in a population of control patients also of non-carrier status and having mild or moderate Alzheimer's disease (*e.g.*, a control population in a clinical trial).

[0289] The invention also provides methods of treating non-carrier patients having Alzheimer's disease (*e.g.*, mild or moderate) in which a regime of an antibody that specifically binds to an N-terminal epitope of Aβ is administered to such a patient. The regime is effective to maintain a mean serum concentration of the antibody in the range of about 0.1 μg/ml to about 60 μg/ml, optionally 0.4-20 or 1-5 μg/ml. Additionally or alternatively, the regime is administered to maintain a mean plasma concentration of Aβ of 600-3000 pg/ml, 700-2000 pg/ml or 800-100 pg/ml. Optionally, the antibody in such methods is bapineuzumab.

[0290] The invention also provides methods of treating a patient who is an ApoE4 carrier and has Alzheimer's disease in which the antibody administered has a constant region mutation that reduces binding to C1q and/or and Fcγ receptor(s). Optionally, the antibody is an antibody that binds to an epitope within an N-terminal region of Aβ. Optionally, the antibody is AAB-003. Optionally, the patients are monitored, *e.g.*, quarterly, by MRI for vasogenic edema. If vasogenic edema develops the frequency or dose can be reduced or eliminated. Vasogenic edema can optionally be treated with a corticosteroid. After resolution of vasogenic edema, administration of treatment can be resumed. Optionally, the dose is increased over time.

[0291] The invention also provides methods of treating a patient diagnosed with probable Alzheimer's disease, irrespective of ApoE4 status. In such methods, an effective regime of an antibody that specifically binds to an N-terminal region of Aβ is administered. The antibody has a constant region mutation that reduces binding to C1q and/or and Fcγ receptor relative to an otherwise identical antibody without the mutation. Optionally, the antibody is an antibody that binds to an epitope within an N-terminal region of Aβ. Optionally, the antibody is AAB-003. Optionally, the patients are monitored, *e.g.*, quarterly, by MRI for vasogenic edema. If vasogenic edema develops the frequency or dose can be reduced or eliminated. Vasogenic edema can optionally be treated with a corticosteroid. After resolution of vasogenic edema, administration of treatment can be resumed. Optionally, the dose is increased over time after resolution of vasogenic edema.

[0292] The invention provides methods of treating an ApoE carrier patient with Alzheimer disease comprising subcutaneously administering to a patient having the disease an antibody that specifically binds to an N-terminal epitope of Aβ. Optionally, the antibody is administered at a dose of 0.01-0.6 mg/kg and a frequency of between weekly and monthly. Optionally, the antibody is administered at a dose of 0.05-0.5 mg/kg. Optionally, the antibody is administered at a dose of 0.05-0.25 mg/kg. Optionally, the antibody is administered at a dose of 0.015-0.2 mg/kg weekly to biweekly. Optionally, the antibody is administered at a dose of 0.05-0.15 mg/kg weekly to biweekly. Optionally, the antibody is administered at a dose of 0.05-0.07 mg/kg weekly. Optionally, the antibody is administered at a dose of 0.06 mg/kg weekly. Optionally, the antibody is administered at a dose of 0.1 to 0.15 mg/kg biweekly. Optionally, the antibody is administered at a dose of 0.1 to 0.3 mg/kg monthly. Optionally, the antibody is administered at a dose of 0.2 mg/kg monthly.

[0293] The invention also provides methods of treating an ApoE4 carrier patient having Alzheimer disease comprising subcutaneously administering to a patient having the disease an antibody that specifically binds to an N-terminal fragment of Aβ, wherein the antibody is administered at a dose of 1-40 mg and a frequency of between weekly and monthly. Optionally, the antibody is administered at a dose of 5-25 mg. Optionally, the antibody is administered at a dose of 2.5-15 mg. Optionally, the antibody is administered at a dose of 1-12 mg weekly to biweekly. Optionally, the antibody is administered at a dose of 2.5-10 mg weekly to biweekly. Optionally, the antibody is administered at a dose of 2.5-5 mg weekly. Optionally, the antibody is administered at a dose of 4-5 mg weekly. Optionally, the antibody is administered at a dose of 7-10 mg biweekly.

VIII. Pharmaceutical Compositions

[0294] Agents of the invention are often administered as pharmaceutical compositions comprising an active therapeutic agent, *i.e.*, and a variety of other pharmaceutically acceptable components. *See* Remington's Pharmaceutical Science (15th ed., Mack Publishing Company, Easton, Pennsylvania (1980)). The preferred form depends on the intended mode of administration and therapeutic application. The compositions can also include, depending on the formulation desired, pharmaceutically-acceptable, non-toxic carriers or diluents, which are defined as vehicles commonly used to formulate pharmaceutical compositions for animal or human administration. The diluent is selected so as not to affect the biological activity of

the combination. Examples of such diluents are distilled water, physiological phosphate-buffered saline, Ringer's solutions, dextrose solution, and Hank's solution. In addition, the pharmaceutical composition or formulation may also include other carriers, adjuvants, or nontoxic, nontherapeutic, nonimmunogenic stabilizers and the like.

[0295] Pharmaceutical compositions can also include large, slowly metabolized macromolecules such as proteins, polysaccharides such as chitosan, polylactic acids, polyglycolic acids and copolymers (such as latex functionalized Sepharose(TM), agarose, cellulose, and the like), polymeric amino acids, amino acid copolymers, and lipid aggregates (such as oil droplets or liposomes). Additionally, these carriers can function as immunostimulating agents (*i.e.*, adjuvants).

[0296] Agents are typically administered parenterally. Antibodies are usually administered intravenously or subcutaneously. Agents for inducing an active immune response are usually administered subcutaneously or intramuscularly. For parenteral administration, agents of the invention can be administered as injectable dosages of a solution or suspension of the substance in a physiologically acceptable diluent with a pharmaceutical carrier that can be a sterile liquid such as water oils, saline, glycerol, or ethanol. Additionally, auxiliary substances, such as wetting or emulsifying agents, surfactants, pH buffering substances and the like can be present in compositions. Other components of pharmaceutical compositions are those of petroleum, animal, vegetable, or synthetic origin, for example, peanut oil, soybean oil, and mineral oil. In general, glycols such as propylene glycol or polyethylene glycol are preferred liquid carriers, particularly for injectable solutions. Antibodies can be administered in the form of a depot injection or implant preparation, which can be formulated in such a manner as to permit a sustained release of the active ingredient.

[0297] Some preferred formulations are described in US 20060193850. A preferred formulation has a pH of about 5.5 to about 6.5, comprises i. at least one Aβ antibody at a concentration of about 1 mg/ml to about 30 mg/ml; ii. mannitol at a concentration of about 4% w/v or NaCl at a concentration of about 150 mM; iii. about 5 mM to about 10 mM histidine or succinate; and iv. 10 mM methionine. Optionally, the formulation also includes polysorbate 80 at a concentration of about 0.001% w/v to about 0.01% w/v. Optionally, the formulation has a pH of about 6.0 to about 6.5 and comprises about 10 mg/ml Aβ antibody, about 10 mM histidine and about 4% w/v mannitol and about 0.005% w/v polysorbate 80 Optionally, the formulation has a pH of about 6.0 to about 6.2 and comprises about 20 mg/ml

Aβ antibody, about 10 mM histidine, about 4% w/v mannitol and about 0.005% w/v polysorbate 80. Optionally, the formulation has a pH of about 6.0 to about 6.2 and comprises about 30 mg/ml Aβ antibody, about 10 mM histidine, about 4% w/v mannitol and about 0.005% w/v polysorbate 80.

[0298] Typically, compositions are prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection can also be prepared. The preparation also can be emulsified or encapsulated in liposomes or micro particles such as polylactide, polyglycolide, or copolymer for enhanced adjuvant effect, as discussed above (*see* Langer, Science 249: 1527 (1990) and Hanes, Advanced Drug Delivery Reviews 28:97 (1997)). The agents of this invention can be administered in the form of a depot injection or implant preparation, which can be formulated in such a manner as to permit a sustained or pulsatile release of the active ingredient.

[0299] Additional formulations suitable for other modes of administration include oral, intranasal, and pulmonary formulations, suppositories, and transdermal applications. For suppositories, binders and carriers include, for example, polyalkylene glycols or triglycerides; such suppositories can be formed from mixtures containing the active ingredient in the range of 0.5% to 10%, preferably 1%-2%. Oral formulations include excipients, such as pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, and magnesium carbonate. These compositions take the form of solutions, suspensions, tablets, pills, capsules, sustained release formulations or powders and contain 10%-95% of active ingredient, preferably 25%-70%.

IX. Kits and Labels

[0300] The invention provides kits containing an antibody binding to an N-terminal epitope of Aβ. The antibody is typically provided in lyophilized or solution form in a vial, optionally in a single-dose form. The antibody in the vial is typically sterile and manufactured under GMP conditions. The kits can also include diluents, syringes, needles, intravenous or subcutaneous drips and the like. The kits typically contain instructions (*e.g.*, a package insert or label) for use. In some kits, the instructions specify whether the antibody is to be provided to ApoE4 carriers or non-carriers or can be provided to both. The instructions can also specify that the antibody is not to be provided to ApoE4 carriers. In some kits, the instructions can provide information or sources for ApoE testing.

[0301] In some kits, the instructions specify results that can be achieved by administering the antibody. The results can include an inhibition of cognitive decline. The instructions can also include a measure of cognitive decline in a control patient (typically a mean value from a population of such patients) for purposes of comparison. Cognitive decline can be measured, by for example, ADAS-COG, NTB, MMSE or CDR-SB Likewise, the instructions can refer to inhibition of decrease in brain volume or inhibition of ventricular volume. The instructions can also include a measure of decrease in brain volume or inhibition of ventricular volume in a control patient (typically a mean value from a population of such patients for purposes of comparison).

[0302] In some kits, the instructions specify potential side effects including vasogenic edema. The instructions can also specify a monitoring regime, such as performing MRI at quarterly, six monthly or annual intervals. The instructions can specify different monitoring regimes for ApoE4 non-carriers and carriers as discussed above. The instructions can also specify altered dosing schedules on occurrence and/or resolution of vasogenic edema and treatment measures for vasogenic edema, such as corticosteroids.

[0303] The kits can also include instructions for patients for whom treatment is contraindicated such as prior brain injury, CVA, brain tumor, multiple lacunes, venothrombotic disease, anticoagulation (heparin/coumadin) or atrial fibrillation. The kits can also provide instructions for route (*e.g.*, subcutaneous), dosage amount or frequency of dosing.

X. Antibodies with mutated IgG1 constant region

[0304] The invention provides a human IgG1 constant region, in which amino acids at positions 234, 235, and 237 (EU numbering) are each alanine, and isolated antibodies or fusion proteins containing such a constant region. Such antibodies include human antibodies, humanized antibodies and chimeric antibodies as described above. Examples of such antibodies include antibodies to Aβ, antibodies to the Lewis Y antigen and the 5T4 tumor antigen, such as described in the Examples. Fusion proteins include the extracellular domains of receptors (*e.g.*, TNF-alpha receptor) linked to a constant region. Methods for fusing or conjugating polypeptides to the constant regions of antibodies are described by, *e.g.*, US Pat. Nos. 5,336,603, 5,622,929, 5,359,046, 5,349,053, 5,447,851, 5,723,125, 5,783,181, 5,908,626, 5,844,095, 5,112,946; EP 0 307 434; EP 0 367 166; EP 0 394 827).

[0305] Antibodies or fusion proteins incorporating these mutations can offer advantages of the IgG1 isotype including pharmacokinetics and ease of manufacture, but also have reduced or eliminated effector function relative to an otherwise identical antibody lacking these mutations. Effector function is typically impaired in binding to one or more Fc gamma receptors, binding to C1Q, antibody-dependent cellular cytotoxicity and/or antibody-dependent complement activity. In some antibodies, all of these activities are reduced or eliminated. An activity is considered eliminated if there is no detectable difference beyond experimental error in that activity between an antibody having the above three mutations and an otherwise identical control antibody without the mutations.

[0306] Typically, a mutated constant region includes CH1, hinge, CH2 and CH3 domains. However, the CH1 domain is sometimes replaced particularly in fusion proteins with a synthetic linker. Some constant regions contain a full-length IgG1 constant region with the possible exception of a C-terminal lysine residue. Exemplary sequences of a mutated constant region are provided by SEQ ID NOS: 62 and 63. These sequences differ in the 62 contains a C-terminal lysine not present in 63.

[0307] The sequences 62 and 63 represent the G1mz allotype of human IgG1. Other examples of allotypes have been provided above. Allotypes are natural polymorphic variations in the human IgG1 constant region that differ between different individuals at the polymorphic position. The G1mz allotype has Glu at position 356 and Met at position 358.

[0308] Other allotypic variants of SEQ ID NOS. 62 and 63 are included. Also included are human IgG1 constant regions having alanine residues at positions 234, 235 and 237 any permutation of residues occupying polymorphic positions in natural allotypes.

[0309] Mutated IgG1 constant regions having alanine at positions 234, 235 and 237 can have additional mutations present relative to a natural human IgG1 constant region. As an example in which additional mutations can be present, alanine mutations at positions 234, 235 and 237 can be combined with mutations at positions 428 and/or 250 as described in US 7,365,168. Mutations at positions 428 and 250 can result in increased half life. Additional mutations that can be combined with mutations at positions 234, 235 and 237 have been described in Section IV A in connection with antibodies that bind Aβ. Some such constant regions have no additional mutations present. Some such constant regions have no additional mutations present in and around regions of the IgG1 constant region affecting Fc gamma receptor and/or complement binding (*e.g.*, residues 230-240 and 325-325 by EU numbering).

The omission of a C-terminal lysine residue by intracellular processing is not considered to be a mutation. Likewise, naturally occurring amino acids occupying polymorphic sites differing between allotypes are considered natural rather than mutant amino acids.

XI. Experimental models, assays and diagnostics

A. Animal models

[0310] Such models include, for example, mice bearing a 717 (APP770 numbering) mutation of APP described by Games *et al.*, supra, and mice bearing a 670/671 (APP770 numbering) Swedish mutation of APP such as described by McConlogue *et al.*, US 5,612,486 and Hsiao *et al.*, *Science*, 274, 99 (1996); Staufenbiel *et al.*, *Proc. Natl. Acad. Sci. USA*, 94:13287-13292 (1997); Sturchler-Pierrat *et al.*, *Proc. Natl. Acad. Sci. USA*, 94:13287-13292 (1997); Borchelt *et al.*, *Neuron*, 19:939-945 (1997)); Richards *et al.*, J. Neurosci. 23:8989-9003, 2003; Cheng, Nat Med. 10(11): 1190-2, 2004 Hwang *et al.*, Exp Neurol. 2004 Mar.. Mutations of APP suitable for inclusion in transgenic animals include conversion of the wild-type Val717 (APP770 numbering) codon to a codon for Ile, Phe, Gly, Tyr, Leu, Ala, Pro, Trp, Met, Ser, Thr, Asn, or Gln. A preferred substitution for Val717 is Phe. Another suitable mutation is the arctic mutation E693G (APP 770 numbering). The PSAPP mouse, which has both amyloid precursor protein and presenilin transgenes, is described by Takeuchi *et al.*, American Journal of Pathology. 2000;157:331-339. A triple transgenic mouse having amyloid precursor protein, presenilin and tau transgenes is described by LaFerla, (2003), Neuron 39, 409-421. Another useful transgenic mouse has both APP and TGF-β transgenes. Protein encoding sequences in transgenes are in operable linkage with one or more suitable regulatory elements for neural expression. Such elements include the PDGF, prion protein and Thy-1 promoters. Another useful transgenic mouse has an APP transgene with both a Swedish and 717 mutation. Another useful transgenic mouse has an APP transgene with an arctic mutation (E693G).

B. Assays to detect amyloid related pathologies

[0311] *Contextual fear conditioning assays.* Contextual fear conditioning (CFC) is a common form of learning that is exceptionally reliable and rapidly acquired in most animals, for example, mammals. Test animals learn to fear a previously neutral stimulus and/or environment because of its association with an aversive experience. (*see, e.g.*, Fanselow,

Anim. Learn. Behav. 18:264-270 (1990); Wehner *et al.*, *Nature Genet.* 17:331-334. (1997); Caldarone *et al.*, *Nature Genet.* 17:335-337 (1997)).

[0312] Contextual fear conditioning is especially useful for determining cognitive function or dysfunction, *e.g.*, as a result of disease or a disorder, such as a neurodegenerative disease or disorder, an Aβ-related disease or disorder, an amyloidogenic disease or disorder, the presence of an unfavorable genetic alteration effecting cognitive function (*e.g.*, genetic mutation, gene disruption, or undesired genotype), and/or the efficacy of an agent, *e.g.*, an Aβ conjugate agent, on cognitive ability. Accordingly, the CFC assay provides a method for independently testing and/or validating the therapeutic effect of agents for preventing or treating a cognitive disease or disorder, and in particular, a disease or disorder affecting one or more regions of the brains, *e.g.*, the hippocampus, subiculum, cingulated cortex, prefrontal cortex, perirhinal cortex, sensory cortex, and medial temporal lobe (*see* US 2008145373).

C. Phagocytosis assays to determine antibody effector function

[0313] Antibodies can be screened for clearing an amyloid deposit in an *ex vivo* assay. A tissue sample from a brain of a patient with Alzheimer's disease or an animal model having characteristic Alzheimer's pathology is contacted with phagocytic cells bearing an Fcγ receptor, such as microglial cells, and the antibody under test in a medium *in vitro*. The phagocytic cells can be a primary culture or a cell line, such as BV-2, C8-B4, or THP-1. A series of measurements is made of the amount of amyloid deposit in the reaction mixture, starting from a baseline value before the reaction has proceeded, and one or more test values during the reaction. The antigen can be detected by staining, for example, with a fluorescently labelled antibody to Aβ or other component of amyloid plaques. A reduction relative to baseline during the reaction of the amyloid deposits indicates that the antibody under test has clearing activity.

[0314] Generally, isotype controls are added to ensure that the appropriate Fc-Fcγ receptor interaction is being observed. Additional controls include use of non-specific antibodies, and/ antibodies with a known affinity for the Fγc receptors on the phagocytic cells. Such assays can be carried out with human or non-human tissues and phagocytic cells, and human, non-human, or humanized antibodies.

[0315] A variation on the *ex vivo* phagocytosis assay eliminates the need for an Aβ-containing tissue, although still allowing detection of the interaction between a particular

antibody and Fcγ receptors. In this case, the assay relies on a solid matrix which is coated with antibody. The solid matrix is generally in a form that can be engulfed by a phagocytic cell, *e.g.*, a bead or particle on the order of nanometers to several microns in size. The solid matrix can be conjugated to a detectable moiety, *e.g.*, a fluorophore, so that the particle can be traced. Kits and materials for phagocytosis assays of this sort are commercially available, *e.g.*, from Beckman Coulter (Fullerton, CA) and Molecular Probes (Eugene, OR). An example of such an assay is provided in the Examples section.

D. Complement binding assays

[0316] Antibody effector function can also be determined by detecting the ability of an antibody to interact with complement, in particular, the C1q polypeptide (*see, e.g.*, Mansouri *et al.* (1999) *Infect. Immun.* 67:1461). In the case of Aβ-specific antibody, a solid matrix (*e.g.*, a multiwell plate) can be coated with Aβ, and exposed to antibody, and, in turn, exposed to labelled C1q. Alternatively, C1q can be attached to the matrix, and labelled antibody added. Alternatively, the antibody can be attached to the matrix and exposed to C1q, followed by detection of C1q. Such *in vitro* binding assays are common in the art and are amenable to modification and optimization as necessary.

E. Diagnostic methods

[0317] *Cognitive function assessment tools.* A number of tools exist to quantify the cognition and mental function of dementia patients. These include the NTB, DAD, ADAS, MMSE, CDR-SOB, NINCDS-ADRDA criteria, and the RMHI (Rosen Modified Hachinski Ischemic) score. These tools are generally known in the art.

[0318] The NTB (Neuropsychological Test Battery) is composed of nine well-accepted tests of memory and executive function. The test battery is acceptable in the most recent EMEA guidance. Patients are generally assessed in the following memory tests periodically: Weschsler Memory Scale Visual Paired Associates; Weschsler Memory Scale Verbal Paired Associates; and Rey Auditory Verbal Learning Test. The Executive function tests include: Wechsler Memory Scale Digit Span; Controlled Word Association Test; and Category Naming Test. This test is sensitive to change in mild AD patients and clinical effects of amyloid lowering agents.

[0319] The DAD (Disability Assessment for Dementia) test was developed and validated to measure the functional disability of patients with Alzheimer's disease (Gelinas *et al.* (1999)

Am J Occup Ther 53:471-81.) Caregivers answer questions about the patients' ability to perform both instrumental and basic activities of daily living that had been attempted in the preceding two weeks. The proportion of DAD activities successfully completed out of those attempted is then determined and reported as a percentage.

[0320] The ADAS-Cog refers to the cognitive portion of the Alzheimer's Disease Assessment Scale (*see* Rosen, *et al.* (1984) *Am J Psychiatry* 141:1356-64.) The test consists of eleven tasks that measure disturbances in memory, language, praxis, attention and other cognitive abilities.

[0321] The NINCDS-ADRDA (Neurological and Communicative Disorders and Stroke-Alzheimer's disease Related Disorders Assessment) measures eight criteria affected in Alzheimer's: memory, language, perceptual skills, attention, constructive abilities, orientation, problem solving , and functional abilities (McKhann *et al.* (1984) *Neurology* 34: 939–44)

[0322] The MMSE (Mini Mental State Exam), CDR-SOB (Clinical Dementia Rating- Sum of Boxes, and RMHI (Rosen Modified Hachinki Ischemic) score are also known in the art (*see, e.g.*, Folstein *et al.* (1975) *J Psych Res* 12: 189–198; Morris (1993) *Neurology* 43: 2412–2414; and Rosen *et al.* (1980) *Ann Neurol.* 17:486-488).

[0323] *Biomarkers.* Biomarkers for Alzheimer's symptomology in humans can be measured using MRI volumetrics, blood and CSF protein levels, and PET (positron emission topography). For example, biomarkers to support antibody-Aβ engagement include Aβ40 and Aβ42 in the CSF and plasma, and amyloid plaque imaging, *e.g.*, by PET. Biomarkers pointing to disease modification include brain morphology (MRI), CSF tau and phosphotau levels, and again, amyloid plaque imaging.

XII. EXAMPLES

Example 1: Phase 1 Trial

[0324] 111 patients with a diagnosis of probable Alzheimer's disease (mild to moderate) were administered the humanized antibody bapineuzumab at doses ranging from 0.15 to 2.0 mg/kg in a multiple ascending dose study (MAD). Antibody was administered by intravenous infusion every thirteen weeks until the dosing regime is complete. Patients were also classified for ApoE4 status. Table 2 shows that eleven patients in the study experienced vasogenic edema detected by MRI. Table 2 also shows symptoms experienced in some of these patients; in other patients the vasogenic edema was asymptomatic. Table 3 shows the risk of vasogenic edema stratified by genotype irrespective of dose. The risk is only 2% in patients lacking an E4 allele but is 35% in patients with two E4 alleles. Table 4 shows the risk of vasogenic edema in only the highest dose group (2 mg/kg). The risk of vasogenic edema for patients with two E4 alleles is 60% and that for patients with one allele is 35%.

[0325] Table 5 shows the risk of vasogenic edema at different dosages. The risk of vasogenic edema is very low for all genotypes for doses between 0.15-0.5 mg/ml but starts to become significant for patients with two E4 alleles at a dose of 1 mg/kg and for patients with one E4 allele at 2 mg/kg. These data indicate that the risk of vasogenic edema is dependent on both ApoE genotype and dose and patients.

TABLE 2

Study	Dose (mg/kg)	Dose #	E4 status	Symptoms
SAD	5	1	ND	-
SAD	5	1	ND	-
SAD	5	1	ND	dizziness, confusion
MAD	0.15	2	4/4	abn gait, confusion
MAD	1	1	4/4	visual
MAD	1	1	4/4	-
MAD	1	2	3/4	-
MAD	2	1	4/4	-
MAD	2	1	3/4	-
MAD	2	1	4/4	confusion
MAD	2	1	3/4	-

TABLE 2

Study	Dose (mg/kg)	Dose #	E4 status	Symptoms
MAD	2	1	3/4	HA, lethargy, confusion
MAD	2	2	3/4	-
PET	2	1	3/4	-
MAD	2	3	4/4	-

TABLE 3

$ApoE_4$ genotype (alleles)	VE cases genotype/ total VE cases	% of VE cases	VE cases/patients exposed	% of patients exposed
2	6/11	55%	6/17	35%
1	4/11	36%	4/52	8%
0	1/11	9%	1/42	2%

TABLE 4

$ApoE_4$ genotype (alleles)	VE cases genotype/ total VE cases	% of VE cases	VE cases/patients exposed	% of patients exposed
2	3/7	43%	3/5	60%
1	3/7	43%	3/9	33%
0	1/7	14%	1/14	7%

TABLE 5
Number of patients (number developing vasogenic edema)

ApoE4 copy #	0.15 mg/kg	0.5 mg/kg	1.0 mg/kg	2.0 mg/kg
0	13 (0)	11 (0)	9 (0)	14 (1)
1	15 (0)	14 (0)	14 (1)	9 (3)
2	3 (1)	4 (0)	5 (2)	5 (3)

Example 2: Phase 2 Trial

[0326] A randomized double-blind placebo-controlled multiple ascending dose study was conducted on a population of 234 patients randomized from an initial population of 317

screened patients. Patients were assessed for ApoE4 carrier status, but carriers (homozygous and heterozygous) and non-carriers received the same treatment. Inclusion criteria were: probable AD diagnosis; aged 50-85 years; MMSE score 16-26; Rosen Modified Hachinski Ischemic score ≤4; Living at home or in a community dwelling with a capable caregiver; MRI consistent with diagnosis of AD; MRI scan of sufficient quality for volumetric analysis; stable doses of medication for treatment of non-excluded conditions; stable doses of AchEIs and/or memantine for 120 days prior to screen. The main exclusion criteria were: current manifestation of a major psychiatric disorder (*e.g.*, major depressive disorder); current systemic illness likely to result in deterioration of the patient's condition; history or evidence of a clinically important auto-immune disease or disorder of the immune system; history of any of the following: clinically evident stroke, clinically important carotid or vertebro-basilar stenosis/plaque, seizures, cancer within the last 5 years, alcohol/drug dependence within last 2 years, myocardial infarction within the last 2 years, a significant neurologic disease (other than AD) that might affect cognition. Kits of the invention and their accompanying labels or package inserts can provide exclusions for patients meeting any of the above exclusion criteria and any subcombinations thereof.

[0327] Four dose levels were employed (0.15, 0.5, 1.0 and 2.0 mg/kg) together with a placebo. 124 patients received bapineuzumab and 110 received a placebo. Of those patients, 122 and 107, respectively, were analyzed for efficacy. Bapineuzumab was supplied as a sterile aqueous solution in 5 ml vials containing: 100mg of bapineuzumab (20 mg/mL), 10 mM histidine, 10 mM methionine, 4% mannitol, 0.005% polysorbate-80 (vegetable-derived), pH of 6.0. The placebo was supplied in matching vials containing the same constituents except for bapineuzumab. The study medication was diluted in normal saline and administered as a 100 ml intravenous (IV) infusion over ~1 hour

[0328] The treatment period was for 18 months with 6 intravenous infusions at 13 week intervals. Safety follow-up visits, including MRI scans occurred 6 weeks following each dose. Following the treatment period patients were either monitored with a 1 year safety follow up for continued treatment in open label extension. The primary objective of the trial was to evaluate the safety and tolerability of bapineuzumab in patients with mild to moderate Alzheimer's disease. The primary endpoints for the study were (Alzheimer Disease Assessment Scale-Cognitive Subscale (ADAS-Cog), Disability Assessment Scale for Dementia (DAD) together with safety and tolerability). The ADAS-Cog 12 contains an

additional test involving delayed recall of a ten item word list relative to the ADAS-Cog 11. The secondary objective of the study was to evaluate the efficacy of bapineuzumab in patients with mild to moderate Alzhiemer's disease. Other end points were neuropsychological test battery (NTB), neuropsychiatric inventory (NPI), clinical dementia rating sum of boxes (CDR-SB), MRI brain volumetrics, and CSF measures.

[0329] A summary of the total population, the populations broken down by dosage group and populations broken down by carrier status is provided is the following tables.

Table 6

	Demographics and Patient Characteristics	
	All Placebo N=107	**All Bapineuzumab N=122**
Age	67.9	70.1
Gender (% F)	59.8	50.0
Ethnicity (% Caucasian)	95.3	96.7
Years Since Onset	3.7	3.5
ApoE4 (% carrier)	69.8	60.5
Screening MMSE	20.7	20.9
% Cholinesterase or Memantine Use	96.3	95.1

TABLE 7

Bapineuzumab	**Avg MMSE**	**Avg Age**	**Disease Duration**	**Disease Severity**		**% APOE Carrier**	**Con Alz Meds**	**# of patients**	
				Mild	**Moderate**			**Baseline**	**Wk 78**
0.15 mg/kg	20	70	4	29%	71%	64%	100%	31	24
Placebo	20	64	4	33%	65%	46%	96%	26	17
0.5 mg/kg	21	71	4	48%	51%	58%	91%	33	17
Placebo	21	69	4	43%	57%	86%	93%	28	21
1.0 mg/kg	21	69	3	43%	55%	69%	97%	29	25
Placebo	21	69	4	36%	69%	75%	93%	26	21
2.0 mg/kg	2	70	3	63%	34%	53%	90%	29	17
Placebo	21	69	3	56%	44%	70%	100%	27	22
All Bapineuzumab	21	70	4	46%	53%	61%	95%	122	83

TABLE 7

Bapineuzumab	Avg MMSE	Avg Age	Disease Duration	Disease Severity		% APOE Carrier	Con Alz Meds	# of patients	
				Mild	Moderate			Baseline	Wk 78
All Placebo	21	68	4	42%	59%	69%	96%	107	81

TABLE 8

	Carrier		Non-carrier	
	Placebo N=74	Bapineuzumab N=72	Placebo N=32	Bapineuzumab N=47
Age	68.6	71.2	66.1	69.1
Gender (% F)	59.5	48.6	62.5	51.1
Ethnicity (% Caucasian)	97.3	97.2	90.6	95.7
Years Since Onset	3.8	3.7	3.5	3.0
Screening MMSE	21.0	20.6	19.8	21.4
% Cholinesterase or Memantine Use	95.9	98.6	96.9	89.4

[0330] Comparison of the various dosage cohorts with placebo using a linear model of cognitive decline on ADAS-COG and DAD scales did not achieve statistical significance for any of the dosage cohorts or the combined dosage cohorts population.

[0331] The data were reanalyzed using a statistical model not assuming linear decline (a) based on all of the patients in whom efficacy was determined and (b) based only on patients who had received all six dosages ("completers") and not including patients who had dropped out for various reasons. The non-linear model is believed to be more accurate because the cognitive abilities do not necessarily decline linearly with time.

[0332] The results using the non-linear decline model for all of the patients in whom efficacy was determined (ApoE4 carriers and non-carriers combined) are shown in Fig. 1. MITT (modified intent to treat) analysis was done using the repeated measures model without assumption of linearity. Bars above the X-axis represent a favorable result (*i.e.*, inhibited decline) relative to placebo. Although statistical significance was not obtained, a trend was observed for the combined dosage cohorts using the ADAS-cog and NTB scales($0.1 \geq p \geq 0.05$) .

[0333] The results for the completer populations (ApoE4 carriers and non-carriers combined) are shown in Fig. 2. Completers were defined as patients who received all 6 infusions and an efficacy assessment at week 78. Bars above the axis indicate improvement relative to placebo. Statistical significance was obtained for the combined dosage cohorts for ADAS-cog and DAD measurements and a positive trend ($0.1 \geq p \geq 0.05$) was found for NTB measurement.

[0334] Separate analyses were performed for ApoE4 carriers and non-carriers using the non-linear model and (a) all treated patients in whom efficacy was determined and (b) completers.

[0335] Fig. 3 shows the results for all ApoE4 carrier patients in which efficacy was measured. Statistical significance was not found for any of the cognitive scales. Again, MITT analysis used repeated measures model without assumption of linearity. Fig. 4 shows the analysis for ApoE4 carrier completers, as defined above. Again, statistical significance was not found by any of the scales (ADAS-cog, DAD, NTB, and CDR-SB). However, favorable directional changes (bars above the axis) were found particularly for the ADAS-cog and DAD measurements.

[0336] Figs. 5 and 6 show the results for all ApoE4 non-carrier patients in whom efficacy was measured. Statistical significance was obtained for ADAS-cog, NTB, CDR-SB and MMSE measurements for the combined dosage cohorts. Bars above the axis indicate improvement relative to placebo. Fig. 9 shows time course analysis of these parameters (ADAS-cog, upper left, DAD, upper right, NTB, lower left, CDR-SB, lower right). The decline in cognitive performance for treated patients was less than that of placebo at all time points on the ADAS-cog, NTB and CDR-SB scales. Figs. 7 and 8 show the analysis for ApoE4 non-carrier completers, as defined above. Statistical significance was again obtained for ADAS-cog, NTB, CDR-SB and MMSE measurements. Again, bars above the axis indicate improvement relative to placebo.

[0337] MRI was performed up to seven times per patient during the study six weeks after each infusion. Changes in the brain were assessed by brain volume, ventricular volume, brain boundary shift integral and ventricular boundary shift integral. The boundary shift integral (BSI) as a measure of cerebral volume changes derived from registered repeat three-dimensional magnetic resonance scans. The BSI determines the total volume through which the boundaries of a given cerebral structure have moved and, hence, the volume change,

directly from voxel intensities. The ventricular shift integral is a similar measurement of ventricular space changes. Both of these parameters increase as Alzheimer's disease progresses. Thus, inhibition of the increase in these parameters relative to placebo shows a positive (*i.e.*, desired) effect of treatment.

[0338] In the total treated population (carriers and non-carriers) no significant differences were found for changes in brain volume measured by brain boundary shift integral or ventricular volume measured by ventricular boundary shift integral over 78 weeks compared with the placebo population.

[0339] In the treated non-ApoE4 carrier population brain volume decline was significantly lower than the non-ApoE4 placebo population (mean -10.7 cc; 95% CI: -18.0 to -3.4; p=0.004). The increase in ventricular volume compared to placebo was also reduced but the change did not reach statistical significance. There was no significant change in brain volume compared with the ApoE4 placebo population. However, the ventricular volume increased significantly compared to placebo (mean 2.5 cc; 95% CI: 0.1 to 5.1; p=0.037).

[0340] The changes of BBSI in the total population, ApoE4 carrier population and ApoE4 non-carrier population are shown in Figs. 10-12. Fig. 12 (ApoE4 non-carriers) shows a statistically significant separation between the lines for treated patients and placebo. The change in brain volume was reduced in the treated population relative to placebo at all measured time points. Fig. 10 (combined ApoE4 carriers and non-carriers) shows separation of the lines for treated and placebo patients but the results did not reach statistical significance. Fig. 11 (ApoE4 carriers) shows the lines for treated and placebo patients are virtually superimposed. Analysis used repeated measures model with time as categorical, adjusting for APOE4 carrier status. Baseline was whole brain volume and MMSE stratum.

[0341] A trend was observed for reduction in CSF phospho-tau in the bapineuzumab treated patient population relative to the placebo treated population at 52 weeks into the trials (Fig. 13). Phospho-tau is a biomarker associated with Alzheimer's disease. No significant differences were found between CSF levels of tau and Aβ42 between all treated patients and controls. The figure is based on ANCOVA analysis, adjusted for baseline value. One outlier was excluded in the 0.15 mg/kg placebo dose cohort.

[0342] Treatment was generally safe and well tolerated. Vasogenic edema (VE) occurred only in bapineuzumab treated patients. VE occurred with greater frequency in ApoE4

carriers (10) than non-carriers (2) and at greater frequency with increasing dose, there being 8, 3, 0 and 1 episodes at doses of 2.0, 1.0, 0.5 and 0.15 mg/kg respectively. All VE episodes occurred after the first or second dose. Most episodes of VE were detected only by MRI and had no detected clinical symptoms. The VE episodes resolved over weeks to months. In one patient, the VE was treated with steroids. Excluding VE, and excluding the 0.15 mg/kg cohort (which contained patients with more advanced disease than other cohorts), serious adverse events were similar between treated and placebo groups. Adverse events were generally mild to moderate, transient, considered unrelated to study drug, occurred in relatively small proportion of patients and did not appear to be dose-related.

[0343] Serum concentration of bapineuzumab and plasma concentration of Aβ were measured in treated patients over time for the different dosage cohorts as shown in Fig. 14. The Cmax for serum bapineuzumab ranged from about 3.5-50 μg/ml in the different dosage cohorts from 0.15 mg/kg to 2.0 mg/kg. The profile of mean plasma concentration of Aβ mirrored that of mean serum bapineuzumab with the concentration of plasma Aβ rising on dosing with bapineuzumab and declining as the concentration of bapineuzumab declined. The concentration of plasma Aβ ranged from about 500-3000 pg/ml. The variation of plasma concentration of Aβ between different dosage cohorts showed less variation than the variation between doses. For example, increasing the dose from 0.15 mg/kg to 2 mg/kg increases plasma Aβ by about a factor of 2.

The PK parameters after the first infusion of bapineuzumab are summarized in Table 9 below.

TABLE 9

Dose (mg/kg)	Cmax (µg/mL)	Cavg (µg/mL)	Cmin (µg/mL)	Tmax (days)	AUCinf (µg•h/mL)	CL/F (mL/hr/kg)	Vz/F (mL/kg)	T½ (days)
0.15	4.6	0.7	0.1‡	0.1	1794	0.09	76.2	26.7
0.5*	17.7	3.0	1.1 ‡	0.4	7165	0.07	63.7	26.4
1.0	28.0	5.5	1.8 ‡	0.1	13499	0.08	75.4	28.4
2.0	56.3	9.5*	1.7 ‡	0.1	21802*	0.09*	65.8*	20.5*

N=6 unless otherwise specified; *n=5

‡ - trough values of 2nd infusion; all values below limit of quantification for trough of 1st infusion

Abbreviations: Cavg- Average concentration over 13 weeks; Cmin - Minimum concentration ("trough"); Tmax – Time of maximum concentration; AUC inf - Area under Concentration vs. time curve extrapolated to infinity; CLss/F - ratio of the extravascular clearance at steady state (CLss) and extent of bioavailability (F); Vz/F - ratio of apparent volume of distribution at steady state (Vz) and F; t 1/2 - elimination (or terminal) half-life in days.

Conclusions

[0344] 1. The trial provides evidence that ApoE4 carriers and non-carriers react differently to immunotherapy.

[0345] 2. The trial provides evidence that vasogenic edema occurs more frequently in ApoE4 carriers and at higher dosages.

[0346] 3. The trial provides statistically significant evidence of efficacy in non-ApoE4 carriers and in patients receiving at least 6 doses of bapineuzumab (ApoE4 carriers and non-carriers).

[0347] 4. The trial provides evidence of trends or favorable directional changes in a total population (ApoE4 carriers and non-carriers) and ApoE4-carrier population by some measures. Statistical significance might be shown with larger populations. Alternative treatment regimes in these patients such as discussed above are likely to improve efficacy as discussed above.

[0348] 5. The trial provides evidence that the treatment is generally safe and well tolerated.

Example 3: Clinical study of subcutaneous administration of Bapineuzumab in Alzheimer's patients

[0349] Subcutaneous injections are generally easier to administer, which can be a consideration for patients with impaired mental function and coordination, or caregivers administering to an uncooperative patient. It is also easier to do at home, which is less upsetting to the patient, as well as less expensive. Finally, subcutaneous administration usually results in a lower peak concentration of the composition (Cmax) in the patient's system than intravenous. The reduced peak can reduce the likelihood of vasogenic edema.

[0350] For these reasons, a clinical study was designed for subcutaneous administration of bapineuzumab. The primary endpoints for the initial study are safety and bioavailability. Once these are established for subcutaneous administration, the cognitive tests described above will be administered to determine efficacy.

[0351] Under the initial regime, bapineuzumab is administered subcutaneously to patients every 13 weeks for 24 months, for a total of 9 doses. All patients receive a dose of 0.5 mg/kg. Patients are screened and periodically monitored as described in the above examples, *e.g.*, for blood levels of the antibody, heart function, and vasogenic edema.

Example 4: Design of specific mouse and human antibodies

[0352] Variants of humanized and mouse 3D6 antibodies differing in isotype and or constant region mutations were constructed to test effects of reducing effector function on amyloid deposit clearing, cognitive function and microhemorrhaging. Mice treated with antibodies to Aβ proteins often exhibit signs of microhemorrhage in cerebral vessels, which is one factor that my be related to the vasogenic edema observed in human patients undergoing similar treatment.

[0353] An alignment of the CH2 domains of human IgG1, IgG2, and IgG4 with mouse IgG1 and IgG2a are shown in Fig. 15. The alignment highlights the residues responsible for FcR and C1q binding. The C1q binding motif is conserved across species and isotypes. The FcR binding motif is conserved in human IgG1, IgG4, and murine IgG2a.

[0354] The following table discloses the particular modifications made to the CH2 region of the heavy chain. The amino acid numbering is by the EU system. The format is wildtype residue, position, mutant residue.

Table 10
3D6 Derivative Antibodies

3D6 Derivative Antibody	Isotype (species)	Mutated Residues
Bapineuzumab Control AAB-001	IgG1 (human)	---
Humanized 3D6 2m (FcγR)	IgG1 (human)	L234A/G237A (EU numbering)
Humanized 3D6 3m (FcγR) AAB-003	IgG1 (human)	L234A/L235A/G237A (EU numbering)
Humanized 3D6 1m (hinge region)	IgG4 (human)	S241P (Kabat numbering)
3D6 Control	IgG1 (mouse)	---
3D6 1m (FcγR)	IgG1 (mouse)	E233P
3D6 3m (C1q)	IgG1 (mouse)	E318A/K320A/R322A
3D6 4m (Clq)	IgG1 (mouse)	E318A/K320A/R322A/E233P
3D6 Control	IgG2a (mouse)	---
3D6 1m (FcγR)	IgG2a (mouse)	D265A
3D6 4m (FcγR, C1q)	IgG2a (mouse)	L235A/E318A/K320A/K322A

[0355] The epitope-binding regions of 3D6 derivative antibodies are the same, and the kinetics of Aβ binding are comparable. Table 11 discloses the kinetics of the Fc receptor binding to the 3D6 derivative antibodies listed in Table 10. These values were generated as follows.

[0356] For the humanized 3D6 derivative antibodies, the following assay conditions were used. A Biacore 3000 and CM5 chip coated with penta-His (SEQ ID NO: 93) antibody (Qiagen, Cat # 34660) was used in combination with His-tagged domains of human FcγRI, FcγRII, and FcγRIII (R&D Systems, Cat # 1257-Fc, 1330-CD, 1597-Fc). Each receptor was separately captured in one flow cell of the sensor chip by the penta-His (SEQ ID NO: 93) antibody. A solution of the antibody to be tested was injected to enable measurements of

association and dissociation rates to the captured receptor. After measurements were completed, the receptors and experimental antibodies were removed by injection of buffer at pH2.5. The flow cell was then ready for the next cycle. Each cycle was carried out in duplicate, and the same conditions (*e.g.*, concentrations, flow rates, and timing) were used for each sample.

[0357] As indicated by the values in Table 11, bapineuzumab (unmodified Fc region) bound to all of the human FcγR receptors with relatively high affinity. KD for FcγRI was in the nm range, while KD for FcγRII and III were in the μm range. For the latter two, the sensorgrams showed typical fast-on, fast-off kinetics. IgG4 isotype had similar binding to FcγRI, but did not bind FcγRIII, as expected. The two IgG1 derivatives, Hu 3D6 2m and 3m, did not show detectable binding to either FcγRI or FcγRIII.

[0358] For the mouse 3D6 derivative antibodies, similar methods were used to determine binding to mouse FcγRI, II, and III. FcγRI and III are activating receptors, while FcγRII is generally considered to be inhibitory. The antibodies tested were 3D6 IgG2a, 3D6 IgG1, and the IgG1 mutants, 3D6 1m, 3m and 4m. Results are expressed as a relative percentage of 3D6 IgG2a binding. As shown in Table 11, 3D6 IgG2a was the only antibody with detectable FcγRI binding ability. 3D6 IgG1 and the 3D6 3m IgG1 had similar FcγRII and III binding profiles.

TABLE 11
Fc Receptor Binding Ability of 3D6 Antibodies

3D6 Derivative	**Relative Binding Capability* (%)**		
	Human FcγRI**	**Human FcγRII****	**Human FcγRIII****
Bapineuzumab Control	100	100	100
Humanized 3D6 1m	85-95	40-50	0
Humanized 3D6 2m	0	40-50	0
Humanized 3D6 3m AAB-003	0	8-12	0
	Mouse FcγRI**	**Mouse FcγRII****	**Mouse FcγRIII****
3D6 Control IgG2a	100***	100	100
3D6 Control IgG1	0	180	70
3D6 1m IgG1	0	15	10
3D6 3m IgG1	0	180	70

TABLE 11
Fc Receptor Binding Ability of 3D6 Antibodies

3D6 Derivative	Relative Binding Capability* (%)		
	Human FcγRI**	Human FcγRII**	Human FcγRIII**
3D6 4m IgG1	0	25	15

*Defined as the amount of binding in (RU) relative to that of IgG2a control at the steady state
**The mFcγRI and mFcγRIII are activating receptors, mFcγRII is an inhibitory receptor. Another potent activating receptor, mFcγRIV, is not commercially available.
***A steady-state binding was not reached. Kinetic fitting led to an estimate of K_D in the nanomolar range.

[0359] The above results show that that the Hu 3D6 3m (AAB-003) antibody has the most reduced Fc gamma receptor binding of the three tested. Of those tested, the 3D6 1m IgG1 mouse mutant antibody was the most similar to AAB-003, in that its FcγR binding was reduced to near 10% of normal.

Example 5: Mouse studies of 3D6 derivative antibodies

Study design

[0360] One-year old PDAPP mice were exposed to a 6 month treatment paradigm with control or the 3D6 derivative antibodies described in Table 10. The negative control was a mouse IgG2a antibody to an irrelevant, non-amyloid epitope. The mice were injected IP with 3 mg/kg of the indicated antibody each week.

[0361] Serum antibody concentrations were tested over the course of the study by ELISA. Levels were comparable in all groups. After six months, the mice were sacrificed and perfused. Brain sections and tissues were prepared according to known methods (Johnson-Wood *et al.* (1997) *Proc. Natl. Acad. Sci., USA* 94:1550-55).

[0362] Amyloid burden was measured in the cortex and hippocampus of transgenic mice. Results in Table 12A and 12B are indicated as percentage reduction of area with amyloid (*p* values indicate significant difference compared to IgG2a control antibody).

TABLE 12A

Cortical Amyloid Burden (% reduction)

	Control IgG2a	3D6 Control IgG2a	3D6 Control IgG1	3D6 1m IgG1 (FcγR)	3D6 3m IgG1 (C1q)
Median % Area	6.25076	0.757259	1.24205	2.06056	1.50084
Range	0.069-17.073	0-9.646	0-17.799	0-24.531	0-17.069
% Change Control IgG2a	---	88 *p<0.0001*	80 *p<0.0001*	67 *p<0.003*	76 *p<0.0001*
% Change 3D6 IgG1	---	---	---	**165.9**	**120.8**
Number	32	34	36	36	34

TABLE 12B
Hippocampal Amyloid Burden (% reduction)

	Control IgG2a	3D6 Control IgG2a	3D6 Control IgG1	3D6 1m IgG1 (FcγR)	3D6 3m IgG1 (C1q)
Median % Area	20.36	8.462	12.29	12.18	8.435
Range	4.707-35.79	1.467-17.59	0.2449-18.61	0-26.99	0.8445-18.61
% Change Control IgG2a	---	58 *p<0.0001*	40 *p<0.0001*	40 *p<0.0001*	59 *p<0.0001*
% Change 3D6 IgG1	---	---	---	**0.895**	**31.4**
number	34	34	37	37	34

[0363] The above results indicate that all of the 3D6 antibodies (IgG2a, IgG1 and mutants) significantly reduced amyloid burden relative to negative controls. Differences between the tested antibodies were not statistically significant.

[0364] The effect of the 3D6 derivative antibodies was then tested on vascular amyloid ratings. Table 13 shows the number of mice with the indicated vascular amyloid rating and the percentage of animals with a rating of 4 or greater (*p* values indicate significant difference compared to 3D6 IgG2a antibody).

TABLE 13
% of Mice Having Vascular Amyloid

	None- little (0-3)	Moderate (4+)	Percentage with moderate rating

Control IgG2a	11	24	69	***p<0.0001***
3D6 Control IgG2a	27	7	21	----------
3D6 Control IgG1	12	25	68	***p<0.0001***
3D6 1m (FcγR) IgG1	15	21	58	***p<0.0016***
3D6 3m (C1q) IgG1	20	17	46	***<0.0434***

[0365] The above data show that the positive control 3D6 IgG2a significantly reduced vascular amyloid relative to the irrelevant IgG2a antibody. The reduction with 3D6 IgG2a was also statistically significant relative to that with 3D6 IgG1, 3D6 1 m IgG1 and 3D6 3 m IgG1. Differences between 3D6 IgG1, 3D6 1 m IgG1 and 3D6 3 m IgG1 and control IgG2a were not statistically significant.

[0366] To determine whether the 3D6 antibody derivatives cause microhemorrhage in mice, hemosiderin levels, a marker for microhemorrhage, were examined in brain sections of mice treated with 3 mg/kg antibody. Staining was carried out with 2% potassium ferrocyanide in 2% hydrochloric acid, followed by a counterstain in a 1% neutral red solution. Table 14 indicates the percentage and absolute number of mice with the indicated level of hemosiderin staining. The results demonstrate that 3D6 1m IgG1 (FcγR) and 3D6 3m IgG1 (C1q), which are shown above to be effective in clearing amyloid plaques, reduce microhemorrhage levels relative to 3D6 IgG2a. Differences between 3D6 IgG1, 3D6 1m IgG1 and 3D6 3m IgG1 did not reach statistical significance, although the difference between 3D6 1m IgG1 and 3D6 IgG1 showed a trend. (*p* values indicate significant difference compared to 3D6 IgG2a antibody).

TABLE 14

Microhemorrhage level:	0	1	2	3
Control IgG2a *p<0.0001*	68% (23)	32% (11)	0% (0)	0% (0)
3D6 Control IgG2a ----------	9% (3)	42% (14)	27% (9)	21% (7)
3D6 Control IgG1 *p<0.0023*	38% (14)	46% (17)	3% (1)	13% (5)
3D6 1m IgG1 (FcγR) *p<0.0001*	51% (19)	49% (18)	0% (0)	0% (0)
3D6 3m IgG1 (C1q) *p<0.0001*	53% (19)	42% (15)	0% (0)	5% (2)

Example 6: Phagocytosis assays

Materials and methods

[0367] *Ex vivo* plaque phagocytosis assays: Frozen brain sections from PDAPP mice were pre-incubated with 3D6 IgG1 and the effector function mutants described in Table 10 (3D6 1m (FcγR1) and 3D6 3m (C1q), both mouse IgG1 isotype). 3D6 IgG2a was used as a positive control and irrelevant IgG1 and IgG2a antibodies were used as isotype controls. Sections were treated with 0.3 or 3 μg/ml antibody for 30 minutes prior to addition of mouse microglia, at 5% CO2 at 37C. The co-cultures were extracted the next day. Remaining Aβ was measured by ELISA (266 antibody for capture, and 3D6-B for reporter) to assess Aβ clearance.

[0368] Phagocytosis of murine IgG2a derivatives was tested. These experiments included: 3D6 IgG2a (positive control); non-specific IgG2a (negative control); 3D6 1m (FcγR1, IgG2a isotype); and 3D6 4m (FcγR1/C1q) antibodies. Conditions were similar to those described above.

[0369] Non-plaque phagocytosis was additionally determined for humanized 3D6 (Hu 3D6 IgG1) and the effector mutants described in Table 10 (Hu 3D6 2m IgG1, Hu 3D6 3m IgG1,

and Hu 3D6 1m IgG4). The negative control was an irrelevant human IgG1 antibody. Assay and detection conditions were otherwise the same.

[0370] *In vitro* assays: For the mouse antibody assays of fluorescently conjugated bead phagocytosis, 10 μM FluoroSphere particles (5x106) were opsonized with 1 mg/ml of mouse F(ab'2) , 3D6 IgG2a, 3D6 IgG1, or the 3D6 FcγR mutant for 2 hrs at RT with rotation. Following 2 hrs, beads were washed with 1ml of PBS 3 times to remove unbound IgG. Opsonized particles were added (1:10) to mouse microglia for the murine 3D6 Ig2a (3D62a) experiments. Beads were incubated with the cells for 90 min at 37C. Unbound particles were then washed away with PBS. Cells were stained with DiffQuick for 30 sec for each stain and phagocytosis was visualized by light microscopy. Controls for this assay were un-opsonized beads (unlabelled) (to detect non-specific engulfment) and pre-treatment with human Fc-fragments (3D62a + FC)(to block FcγR1).

[0371] For humanized antibody assays, conditions and detection were the same. However, the antibodies were: no antibody (unlabelled; negative control), irrelevant human IgG1 (Human IgG1; positive control), Hu 3D6 IgG1, Hu 3D6 2m IgG1, Hu 3D6 3m IgG1, and Hu 3D6 1m IgG4. The phagocytic cells were human THP-1 cells (differentiated with PMA).

Results

[0372] *Ex vivo* plague phagocytosis assays: The murine 3D6 IgG1 antibody and its effector mutants (3D6 1m (FcγR1) and 3D6 3m (C1q)) were assayed to assess their ability to facilitate amyloid clearance (*see* Fig. 16). The 3D6 IgG2a antibody stimulated more robust clearance than 3D6 IgG1, 3D6 1m (FcγR1) and 3D6 3m (C1q). Stimulation of phagocytosis by 3D6 IgG1, 3D6 1m (FcγR1) and 3D6 3m (C1q) was greater than the negative control. Mutations to the Fc domain of 3D6 IgG1 do not appear to significantly dampen its ability to stimulate clearance in the *ex vivo* clearance assay.

[0373] For the IgG2a 3D6 derivatives, the mutants stimulated clearance equivalent to wild-type 3D6 IgG2a and to a greater degree relative to an irrelevant IgG2 isotype matched control (*see* Fig. 17). Thus, neither of the mutants completely inhibited Aβ phagocytosis.

[0374] In the humanized antibody assays, mutations to the effector region of the Hu 3D6 IgG1 retained significant clearing activity relative to the negative control. Hu 3D6 IgG1 stimulated clearance in the *ex vivo* Aβ plaque clearance assay, and the effector region mutants had moderately impaired function. Hu 3D6 IgG4 induced phagocytosis to the same extent as

Hu 3D6 IgG1, and mutation to the IgG4 hinge region of 3D6 did not appear to change its effector function (*see* Fig. 18).

[0375] *In vitro* bead phagocytosis assays: To determine if the *ex vivo* results were specific for Aβ clearance and whether the Fc mutation in the 3D6 IgG1 altered its effector function, non-specific Fc-mediated bead phagocytosis assays were performed. In the mouse antibody bead phagocytosis assay, the 3D6 IgG2a isotype antibody mediated more efficient phagocytosis than 3D6 IgG1 (*see* Fig. 19). The Fc mutation in 3D6 IgG1 did not significantly diminish the ability to stimulate phagocytosis, as compared to the positive control 3D6 IgG2a, indicating that the Fc mutation in 3D6 IgG1 was moderately effective in reducing phagocytosis.

[0376] In the humanized antibody assay, the effect of the Fc mutation seen in the e*x vivo* plaque phagocytosis assay was verified on Fc-mediated bead phagocytosis. Again, the mutations in the Fc portion of humanized 3D6 diminished its ability to mediate phagocytosis of fluorescent beads and there was no significant difference between the 2m and 3m mutants. Again, the theoretically ineffective IgG4 isotype mediated removal to the same extent as the IgG1 isotype (*see* Fig. 20). Mutation to the IgG4 hinge region of 3D6 does not appear to change its effector function.

Example 7: C1q Binding Ability of Humanized 3D6 Derivatives

[0377] The humanized 3D6 derivatives were tested for ability to bind C1q and induce a complement response. A standard C1q dilution series protocol was followed, as described below. Similar protocols are described, *e.g.*, in Idusogie *et al.* (2000) *J. Immunol.* 164: 4178-4184.

[0378] Purified Aβ was coated on to ELISA plates and exposed to one of the following humanized 3D6 antibodies at the concentrations indicated in Fig. 21: Hu 3D6 2m (IgG1), Hu 3D6 3m (IgG1), Hu 3D6 1m (IgG4), and unmodified Hu 3D6 (IgG1). The ELISA plates were washed and then blocked with 0.02% Casein solution in PBS for 3 to 24 hours with slow agitation. The blocking solution was removed with another step of washing.

[0379] Next, purified human C1q (191391, MP Biomedicals) was added to the ELISA plates, with 2 ug C1q /ml assay buffer starting the 2X dilution series. C1q was allowed to bind for 2 hours with agitation. Following another wash step, 100µl/ well anti-C1q antibody (Rb anti human C1q FITC conjugated cat# F010 DBS (dbiosys.com)) used at 1:200 was

added for 1 hour with agitation. Results were compared to a blank with no anti-C1q antibody.

[0380] As shown in Fig. 21, the humanized 3D6 derivative antibodies did not significantly interact with C1q. This is in contrast to bapineuzumab, which does not have mutations in the Fc region.

[0381] The derivative antibodies were tested for ability to induce complement-mediated lysis of HEK 293 cells expressing Aβ on the surface. A standard ^{51}Cr release assay was used, as described in Phillips *et al.* (2000) *Cancer Res.* 60:6977-84; Aprile *et al.* (1981) *Clin. Exp. Immunol.* 46:565-76.

[0382] The target cells were HEK293 cells (ATCC, CRL-1573) that expressed a fusion protein with the Aβ epitope detected by 3D6 (DAEFR (SEQ ID NO: 94)) on the surface. The Aβ-containing sequence was inserted into the pDisplay vector (Invitrogen). The pDisplay vector was altered to remove the HA tag and instead start with the Aβ-containing peptide after leader sequence. A stable pool of HEK 293 was moved forward to the ADCC assay.

[0383] For labeling, 10^7 cells were suspended in 2ml RPMI 10% FCS and added 250uCi of ^{51}Cr (NEN catalog #NEZ-030; sodium^{51}chromate in saline). Cells were incubated for 1 hour at 37C with occasional agitation. At the end of the incubation, 10 ml RPMI with 10% FCS was added. Cells were spun down so the supernatant could be removed, and resuspended in 10 ml RPMI containing 10% FCS. Cells were again incubated, at room temperature for 1.5 hours with occasional agitation, to allow excess ^{51}Cr to bleed from the cells. Target cells were washed 3 times with 10ml RPMI, and a final time in 10 ml RPMI containing 10% FCS. Cells were resuspended in RPMI with 10% FCS to a concentration of 10^6 cells/ ml.

[0384] Effector cells were collected from human blood. Briefly, blood was diluted 1:1 with PBS and layered over Ficoll (Sigma Histopaque 1077). The column was spun for 20 min, 1200 x g, with no brake at 20C. Cells at the interface were collected; washed once with 2-3 volumes PBS, and twice with RPMI containing 10% FCS. NK enrichment is detected with antibodies to CD3 and CD56.

[0385] Effector cells and target cells were added to 96 well plates at a ratio of 25:1 (effector:target) in a total volume of 200μl. The following control samples were included: Spontaneous lysis (containing target cells with no effectors) and Total lysis (leave wells empty) was included. The cells were incubated for 5 hours at 37C. Just before harvest, 100

µl 0.1% Triton X-100 was added to the Total lysis sample to release ^{51}Cr. The reactions were harvested onto filter units with a Skatron harvester (Molecular Devices) and total ^{51}Cr was detected.

[0386] To calculate % lysis, the average cpm and standard deviation was determined for each sample. The % Maximum ^{51}Cr Release is determined with the following formula:

$$\frac{\text{(Experimental - Spontaneous)}}{\text{(Total - Spontaneous)}} \times 100$$

[0387] Consistent with the results of the C1q binding assay, the humanized 3D6 effector function mutant derivative antibodies were not effective at inducing complement lysis of the Aβ-expressing HEK 293 cells (*see* Fig. 22).

Example 8: ELISA Assay Measuring C1q Binding Ability of Murine 3D6 Derivatives

Materials and methods

[0388] A 96-well fluorescent plate was coated with 1, 3, or 6 µg/ml of various antibodies in 100 µl well coating buffer overnight at 4C. After coating, plates were washed and blocked with 200 µl Casein Elisa Block for 1 hr at RT. Plates were washed and 100 µl of 2 µg/ml human C1q in diluent buffer was added for 2 hrs at RT. After 2 hrs, plates were washed and FITC-labelled rabbit anti-C1q (1:1000) was added for 1 hr. Plates were washed twice and read at 494/517 on the fluorescent plate reader in PBS. The following mouse antibody samples were tested: IgG2a, IgG2b, 3D6 IgG2a, IgG1, 3D6 IgG1, and the 3D6 IgG1 C1q mutant.

Results

[0389] The highest level of C1q binding was observed for IgG2a and 3D6 IgG2a (*see* Fig. 23). C1q binding to IgG1 and 3D6 IgG1 was significantly lower than IgG2a. The mutation in 3D6 IgG1 C1q binding domain suppressed this binding further.

Example 9: Contextual Fear Conditioning (CFC) Assay

[0390] Tg2576 transgenic mice and wild-type littermate controls were individually housed for at least 2 weeks prior to any testing and allowed ad libitum access to food and water. CFC occurred in operant chambers (Med Associates, Inc.) constructed from aluminum sidewalls and PLEXIGLAS ceiling, door and rear wall. Each chamber was equipped with a floor through which a foot shock could be administered. In addition, each chamber had 2

stimulus lights, one house light and a solenoid. Lighting, the footshock (US) and the solenoid (CS) were all controlled by a PC running MED-PC software. Chambers were located in a sound isolated room in the presence of red light.

[0391] Mice (n = 8-12/genotype/treatment) were trained and tested on two consecutive days. The Training Phase consisted of placing mice in the operant chambers, illuminating both the stimulus and house lights and allowing them to explore for 2 minutes. At the end of the two minutes, a footshock (US; 1.5 mAmp) was administered for 2 seconds. This procedure was repeated and 30 seconds after the second foot shock the mice were removed from the chambers and returned to their home cages.

[0392] Twenty hours after training, animals were returned to the chambers in which they had previously been trained. Freezing behavior, in the same environment in which they had received the shock ("Context"), was then recorded using time sampling in 10 seconds bins for 5 minutes (30 sample points). Freezing was defined as the lack of movement except that required for respiration. At the end of the 5 minute Context test mice were returned to their home cages.

[0393] Approximately 20-week old wild-type mice and Tg2576 transgenic mice were administered a single dose of treatment antibody by intraperitoneal injection at 24 hours prior to the training phase of the CFC. Treatment antibodies were: (i) non-specific IgG1 antibody; (ii) Hu 3D6 3m (FcγR) (also called AAB-003); and (iii) bapineuzumab (also called AAB-001).

[0394] Fig. 24 demonstrates the results. Control-treated wild type mice showed about 40% freeze, while in comparison, control-treated transgenic mice exhibited a severe deficit in contextual memory. When administered at 30 mg/kg, the Hu 3D6 3m antibody restored cognitive function to wild type levels. Furthermore, the effector function mutant had the same effect on contextual memory as the parent antibody, bapineuzumab.

[0395] The effect of the Hu 3D6 3m antibody on contextual memory was observed over time. Fig. 25 illustrates that treatment with 30 mg/kg Hu 3D6 3m antibody provided wild type levels of cognition at least 5 days post-administration.

[0396] In summary, the above examples show that Hu 3D6 3m results in similar cognition improvements as bapineuzumab. This is despite the fact that the derivative antibody does not significantly bind to Fc receptors or C1q, or induce phagocytosis or ADCC activity.

Example 10: Mouse studies with 3D6 4m (FcγR/ C1q) IgG2a and Hu 3D6 3m IgG1 (AAB-003)

Study design

[0397] One-year old PDAPP mice are exposed to a 6 month treatment paradigm with control; 3D6 4m (FcγR/ C1q) IgG2a; or Hu 3D6 3m IgG1 (*see* Table 10). Negative controls include a mouse IgG2a antibody and a human IgG1 antibody to an irrelevant, non-amyloid epitope. Positive controls include 3D6 IgG2a and Hu 3D6 IgG1. The mice are split into dosage cohorts and injected IP at weekly intervals with 3, 30, or 300 mg/kg of the indicated antibody. Experimental conditions are as described in Example 5.

[0398] After 6 months, the mice are sacrificed and brain tissue harvested as described above. Tissues are examined for cortical and hippocampal Ab and amyloid burden, vascular amyloid, and microhemorrhage.

Example 11: Cynomolgus monkey studies with Hu 3D6 3m IgG1 (AAB-003)
Study design

[0399] Cynomolgus monkeys are treated with Hu 3D6 3m IgG1 (AAB-003). The negative control includes a human IgG1 antibody to an irrelevant, non-amyloid epitope. The positive control include Hu 3D6 IgG1 (Bapineuzumab). Monkeys are split into dosage cohorts receiving either 15, 50, or 150 mg/kg of the indicated antibody. Each cohort is further split into IV and SC administration groups.

[0400] Monkeys are injected weekly for 13 weeks, with a 2 month observation period. At the end of the study, the monkeys are sacrificed and brain tissue harvested. Tissues are examined for cortical and hippocampal Aβ and amyloid burden, vascular amyloid, and microhemorrhage.

Example 12: Single Ascending Dose (SAD) study in humans of Hu 3D6 3m (AAB-003) antibody

[0401] Mild to moderate Alzheimer's patients, including ApoE4 carriers and non-carriers, are divided into cohorts for intravenous (IV) or subcutaneous (SC) injection with AAB-003 antibody. The cohorts are given a single dose with a 12 month follow up, and monitored throughout by an independent safety monitoring committee.

[0402] The goal of the study is to increase the exposure equivalent to at least 5 mg/kg of intravenous Bapineuzumab (unless signs of vasogenic edema are observed). At this dose of Bapineuzumab, VE was observed in 3 of 10 patients.

[0403] The SC cohorts include at least two subcutaneous dosage levels. These patients are be observed for bioavailability of the antibody and linearity thereof.

[0404] All patients are screened (*e.g.*, for ApoE status) and monitored as described in Example 1. For all cohorts, safety monitoring includes MRI monitoring. MRI results are compared to those from the Bapineuzumab study described in the above examples. Efficacy is measured by cognitive metrics (*e.g.*, NTB, DAD, ADAS-Cog,); plasma Aβ levels; CSF levels of amyloid, tau, and phosphotau; and amyloid imaging.

[0405] Certain biomarkers are tracked in each patient during the study. Biomarkers to support Aβ binding by the antibody include Aβ40 and Aβ42 in the CSF and plasma, and amyloid plaque imaging, *e.g.*, by PET. Biomarkers pointing to disease modification include MRI, CSF tau and phosphotau levels, and again, amyloid plaque imaging.

Example 13: Pharmacokinetic profiles of Hu 3D6 3m (AAB-003) in Tg2576 and wild type mice

[0406] Tg2576 transgenic mice and wild type controls were dosed with AAB-003 subcutaneously (SC) or intraperitoneally (IP) to determine bioavailability of the antibody. The profile was typical for therapeutic antibody.

[0407] AAB-003 was eliminated slowly, with a T1/2 of 66-160 hours. There was low volume distribution (71-96) and good exposure (as measured by AUC).

[0408] Some differences between the wild type and transgenic mice were apparent. For example, wild type mice had higher AUC and T1/2. The transgenic mice had slightly higher levels of anti-AAB-003 antibodies.

Example 14: Pharmacokinetic profiles of Hu 3D6 3m (AAB-003) in cynomolgus monkeys

[0409] 10 mg/kg Hu 3D6 3m or bapineuzumab were administered intravenously (IV) to cynomolgus monkeys (3 animals/ antibody treatment) to compare the pharmacokinetic profiles and determine whether the effector function mutation had any effect. The results were comparable between the two antibodies, and typical for therapeutic antibodies in

general. There was low clearance (0.16 ± 0.06 ml/hr/kg), small volume of distribution (~62 ml/kg), and long elimination half-life (309 ± 226 hours). One of the three animals tested positive for antibodies against AAB-003.

[0410] The same antibody doses were administered subcutaneously (SC). Bioavailability was good, approximating 69%, and the half-life ranged from 21-445 hours. Two of the three animals tested positive for antibodies against AAB-003.

Example 15: Effect of Fc mutations on the effector function of an anti-Lewis Y antibody

[0411] To determine the effect of mutations in the low hinge region of human IgG1 on the effector function of antibodies with different antigen specificity, we designed antibodies to the Lewis Y (LeY) antigen. LeY is a type 2 blood group related difucosylated oligosaccharide that is mainly expressed in epithelial cancers, including breast, pancreas, colon, ovary, gastric, and lung. LeY does not appear to be expressed on tumors of neuroectodermal or mesodermal origin.

[0412] The anti-LeY Ab02 antibody was generated with one of three heavy chain constant regions: (i) wild type human IgG1; (ii) wild type human IgG4; and (iii) human IgG1 with two effector region mutations, L234A and G237A (*see* SEQ ID NOs:50 and 51). IgG4 has been shown to have reduced effector function in other systems.

[0413] For the ADCC (antibody-dependent complement cytotoxicity) assay, LeY-overexpressing N87 human gastric adenocarcinoma cells were used as target cells, and freshly isolated human PBMC were used as effector cells. Effector and target cells were plated at a ratio of 50:1 in 96 well plates. Antibody was applied at varying concentrations (0.1, 1 and 10 μg/ml) in triplicate with medium, effector and target cell controls, and antibody controls. The ADCC activities of anti-Lewis Y Ab02 versions are presented in Fig. 26.

[0414] For the CDC (complement dependent cytotoxicity) assay, LeY positive tumor cells (A431 LeY) were plated in 96 well plates with varying amount of antibody (0.1, 1 and 10 μg/ml). Diluted human complement (1:100), was added to each well. Tests were done in triplicate at a final volume of 100 μl/ml with medium, cells alone, and antibody and complement controls. After 4 hours incubation at 37 C, plates were removed and equilibrated to 22 C.

[0415] An equal volume of CytoTox-One ™ was added to each well, and incubated for 10 minutes at 22 C. As a positive control, 2 μl of lysis buffer per well (in triplicate) was added

to generate a maximum LDH (lactate dehydrogenase) release in control wells. The enzymatic reaction was stopped by adding 50 µl of stop solution. The resulting fluorescence was recorded with an excitation wavelength of 560 nm and an emission wavelength of 590 nm. The % of complement-related cell lysis was calculated as % of total LDH release (Fig. 27).

[0416] In spite of the L234A and G237A mutations in IgG1, the mutant antibody fully retained its capacity to mediate both ADCC and CDC against Lewis Y expressing tumor cells, as compared to wild type IgG1.

Example 16: Effect of Fc mutations on the effector function of anti-5T4 antibody

[0417] To investigate further the effect of Fc mutations in human IgG1 on the effector function of antibodies with different antigen specificity, we designed antibodies to the oncofetal protein 5T4. 5T4 is a tumor-associated protein displayed on the cell membrane of various carcinomas, and is a promising target for anti-tumor vaccine development and for antibody directed therapies.

[0418] The anti-5T4 antibody was generated with different combinations of mutations in the heavy chain constant region. The heavy chains used were: (i) wild type human IgG1; (ii) wild type human IgG4; (iii) human IgG1, L234A and L235A; (iv) human IgG1, L234A and G237A; (v) human IgG1, L235A and G237A; and (vi) human IgG1 with three effector region mutations, L234A, L235A, and G237A (*see* SEQ ID NOs:62 and 63).

[0419] Human breast carcinoma cell line MDAMB435, stably transfected with 5T4 antigen, was used for the ADCC and CDC assays. The ADCC assay of anti-5T4 antibodies was as described in Example 15, using freshly isolated human PBMC as effector cells at an effector:target cell ratio 50:1. MDAMB435-Neo transfected cells were used as a negative control. The results of ADCC activity (maximum specific cytotoxicity at the antibody concentration 10ug/ml) are summarized in Table 15.

TABLE 15
ADCC activity of anti-5T4 antibodies against 5T4 positive and negative human breast carcinoma cell line MDAMB435

Antibody	MDAMB345-5T4 % specific cytotoxicity	MDAMB-Neo % specific cytotoxicity
5T4-IgG1wt	81	3
5T4-IgG1	78	2

TABLE 15
ADCC activity of anti-5T4 antibodies
against 5T4 positive and negative human breast carcinoma cell line MDAMB435

Antibody	MDAMB345-5T4 % specific cytotoxicity	MDAMB-Neo % specific cytotoxicity
L234A/G237A		
5T4-IgG1 L234A/L235A	15	2
5T4-IgG1 L235A/G237A	27	2
5T4-IgG1 L234A/L235A/G237A	2	2
5T4-IgG1 N297A	5	3
5T4-IgG4	2	2

[0420] To evaluate an effect of Fc mutations on the complement induced cytotoxicity, human breast carcinoma MDAMB435-5T4 cells were incubated with diluted human complement as described in the Example 15. The results of CDC assays are presented in the Table 16.

Table 16
CDC activity of anti-5T4 antibodies against
5T4 positive and negative human breast carcinoma cell line MDAMB435

Antibody	MDAMB345-5T4 % specific cytotoxicity	MDAMB-Neo % specific cytotoxicity
5T4-IgG1wt	90	2
5T4-IgG1 L234A/G237A	72	2
5T4-IgG1 L3234A/L235A	5	2
5T4-IgG1 L235A/G237A	19	2
5T4-IgG1 L234A/L235A/G237A	1	1

Table 16
CDC activity of anti-5T4 antibodies against
5T4 positive and negative human breast carcinoma cell line MDAMB435

Antibody	MDAMB345-5T4 % specific cytotoxicity	MDAMB-Neo % specific cytotoxicity
5T4-IgG1 N297A	1	1
5T4-IgG4	1	1

[0421] The introduction of two mutations in the low hinge region of human IgG1 in any of the combinations tried (L234A/L235 ; L234A/G237A; L235A/G237A) only partially reduced ADCC and CDC activity with L235A/G237A showing the higher residual effecter function capabilities. However, anti- 5T4 antibody with three mutations in the IgG1 low hinge region (L234A/ L235A/G237A) demonstrated completely abolished ADCC and CDC activities.

Conclusions

[0422] The Examples provide a number of comparisons of Fc region mutant antibodies with different antigen specificities. Example 6 describes an ADCC assay using Aβ-specific antibodies with IgG1 Fc mutations at either L234A and G237A (double mutant), or L234, L235A, and G237A (triple mutant). Both the double and triple mutants had significantly reduced function (*see* Fig. 22). Example 15 describes ADCC and CDC assays using LeY-specific antibodies with IgG1 mutations at L234A and G237A. In this case, the mutant antibody retained effector function (*see* Figs. 26 and 27). Finally, Example 16 compares IgG1 Fc mutants of 5T4-specific antibodies. Each of the double mutants (L234A/L235; L234A/G237A; L235A/G237A) retained more effector activity than the triple mutant (L234A/ L235A/G237A) (*see* Tables 15 and 16). The effector activity of the L234A/L235 double mutant, however, was reduced to nearly the same level as that of the triple mutant.

[0423] The above results demonstrate that the effect of the hinge-region mutations can depend on a number of factors, including target antigen density on the cell surface. However, the data indicate that disruptions at all three positions are necessary to eliminate effector activity.

[0424] The above examples are illustrative only and do not define the invention; other variants will be readily apparent to those of ordinary skill in the art. The scope of the invention is encompassed by the claims of any patent(s) issuing herefrom. The scope of the

invention should, therefore, be determined not with reference to the above description, but instead should be determined with reference to the issued claims along with their full scope of equivalents. All publications, references, accession numbers, and patent documents cited in this application are incorporated by reference in their entirety for all purposes to the same extent as if each individual publication or patent document were so individually denoted.

CLAIMS:

1. A humanized 3D6 antibody (ATCC accession number PTA-5130) comprising a human heavy chain constant region with L234A, L235A and G237A mutations, wherein positions are numbered by the EU numbering system.

2. The humanized antibody of claim 1, wherein the isotype is human IgG1, IgG2 or IgG4, preferably IgG1.

3. The humanized antibody of claim 2, comprising a humanized light chain having an amino acid sequence comprising SEQ ID NO:48 and a humanized heavy chain having an amino acid sequence comprising SEQ ID NO:66 or 67.

4. A pharmaceutical composition comprising the humanized antibody of any one of claims 1-3.

5. An isolated nucleic acid encoding the heavy chain of the humanized antibody of any one of claims 1-3, having a sequence comprising SEQ ID NO:68, provided that nucleotides 1-57 encoding a signal sequence may or may not be present.

6. An isolated humanized antibody comprising a mature light chain variable region sequence of SEQ ID NO:2 and a mature heavy chain variable region sequence of SEQ ID NO:3, and a human heavy chain constant region of IgG isotype with L234A, L235A, and G237A mutations, wherein positions are numbered by the EU numbering system.

7. The isolated antibody of claim 6 that has human IgG1 isotype.