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(54) Title: ANTI-AMYLOID BETA ANTIBODIES CONJUGATED TO SIALIC ACID-CONTAINING MOLECULES

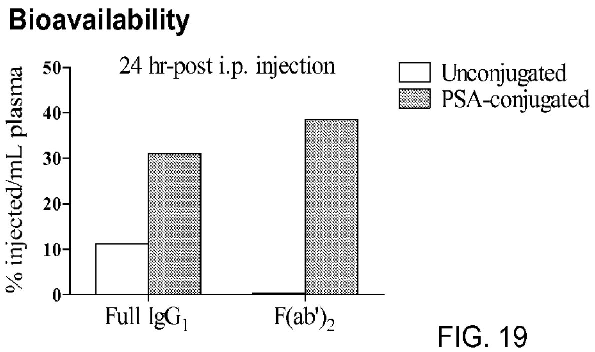

FIG. 19

(57) Abstract: Antibody complexes including anti-Aβ antibodies conjugated with a sialic acid- containing molecule show improved bioavailability with no significant adverse effects on binding to amyloid beta.

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ANTI-AMYLOID BETA ANTIBODIES CONJUGATED TO SIALIC ACID-CONTAINING MOLECULES

RELATED APPLICATION

[01] This application (i) is a Continuation-in Part of U.S. Patent Application Serial No. 12/323,682, filed November 26, 2008, published as US 2009/175923A1 on July 9, 2009, which claims priority to U.S. Provisional Patent Application Serial No. 60/990,401, filed on November 27, 2007, and which is a Continuation-In Part of U.S. Application Serial No. 12/120,269, filed May 14, 2008, which claims the benefit of Provisional Application Serial Nos. 60/917,911, filed May 14, 2007, and 60/984,775, filed November 2, 2007 and (ii) claims priority to U.S. Provisional Application Serial. No. 61/181,646, filed May 27, 2009, each of which prior applications are hereby incorporated herein by reference in their respective entireties to the extent that they do not conflict with the disclosure presented herein.

FIELD

[02] This disclosure relates to polysialic acid conjugated antibodies, particularly antibodies directed to amyloid beta, and methods related thereto.

SEQUENCE LISTING

[03] This application contains a Sequence Listing electronically submitted via EFS-Web to the United States Patent and Trademark Office as text filed named "SEQ_List_ST25.txt" having a size of 42 kb and created on July 16, 2009. Due to the electronic filing of the Sequence Listing, the electronically submitted Sequence Listing serves as both the paper copy required by 37 CFR §1.821(c) and the CRF required by §1.821(e). The information contained in the Sequence Listing is hereby incorporated herein by reference.

BACKGROUND

[04] Amyloid beta or "Aβ" is peptide of between about 39-43 amino acids that corresponds to a peptide formed *in vivo* upon cleavage of an amyloid beta A4 precursor protein (APP or ABPP) by beta-secretase (at the N-terminal portion of Aβ) and gamma secretase (at the C-terminal portion of Aβ). The most common isoforms of Aβ are Aβ40 and Aβ42, 40 and 42 amino acids, respectively. Aβ42 is less common, but is thought to be more fibrillogenic than Aβ40. Aβ is the main constituent of amyloid plaques in brains of Alzheimer's disease patients. Similar plaques can also be found in some Lewy body dementia patients. Such plaques or Aβ aggregates are also found in the cerebral vasculature of cerebral amyloid angiopathy patients.

[05] Central and peripheral administration of antibodies directed to Aβ has been shown to be effective in reducing amyloid plaques and improving cognitive aspects of transgenic models of Alzheimer's disease. However, the administration of antibodies or antibody fragments has had drawbacks that limit their applicability in humans due in part to immunogenicity of the antibodies or fragments. New techniques such as chimerization and humanization have been developed to reduce the immunogeneicity of the antibodies or antibody fragments. Some newly developed antibodies appear to be completely free of epitopes recognized as foreign by the human immune system and may be generated by using transgenic mouse systems or phage/phagemid display.

[06] Such completely humanized antibodies are a driving force behind the fast-paced expansion of antibody product pipelines. The generation of humanized antibodies, however, involves substituting human amino acid sequences for those of the animal in which the antibody was raised. Such alteration of the amino acid structure of an antibody may have unforeseen consequences in the ability of the antibody to bind the epitope to which it is directed.

[07] Further, antibody based therapy, whether humanized or not, may prove to be expensive, due in part to the rate of in vivo clearance of the antibodies. The production of therapeutic antibodies can be costly, and the repeated administration of significant doses of such antibodies can result in escalating health care costs.

BRIEF SUMMARY

[08] Described herein are antibody complexes including an anti-Aβ antibody conjugated to a sialic acid-containing molecule that may improve the bioavailability of the antibody. The antibodies may be humanized anti-Aβ antibodies, such as antibodies derived from a murine antibody directed to a N-terminal epitope of Aβ (e.g., as described in US Patent Application Serial No. 12/323,682, filed on November 26, 2008, and having attorney docket no. P0030103.01, which application is incorporated herein by reference in its entirety to the extent that it does not conflict with the disclosure presented herein). The humanized antibodies described in US Patent Application Serial No. 12/323,682 have reduced or no human T cell epitopes and bind Aβ with an affinity similar to that of the murine antibody. Conjugation of sialic acid-containing molecules to such antibodies may further reduce immunogenicity without significantly adversely affecting the ability of the antibody to bind Aβ.

[09] In various embodiments, an antibody complex presented herein includes anti-Aβ antibody conjugated to a sialic acid-containing molecule. The anti- Aβ includes a variable heavy chain region having an amino acid sequence of **SEQ ID NOs**: **42**, **44**, **46**, or **47-51**, or an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **42**, **44**, **46**, or **47-51**. In some embodiments where the antibody includes a heavy chain variable region having an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **42**, **44**, **46**, or **47-51**, one or more or all of the amino acid differences are conservative substitutions.

[10] In some embodiments, the anti-amyloid beta antibody presented herein includes a light chain variable region amino acid sequence of **SEQ ID NOs**: **43**, **45**, or **52-54**, or an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **43**, **45**, or **52-54**. In some embodiments where the antibody includes a light chain variable region having an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **43**, **45**, or **52-54**, one or more or all of the amino acid differences are conservative substitutions.

[11] Of course, any possible combination of such heavy chain and light chain amino acid sequences are contemplated herein. In some embodiments, a humanized antibody includes (i) a heavy chain variable region having an amino acid sequence of any of **SEQ ID NOs: 47-51** and (ii) a light chain variable region having an amino acid sequence of any of **SEQ ID NOs: 52-54**.

[12] The antibody complexes, as described herein, may be used for any suitable purpose including treating or studying a neurological disease in a subject.

[13] In various embodiments, a method for treating a disease associated with increased or aberrant soluble Aβ, Aβ fibrils or Aβ plaques in a subject in need thereof includes administering an effective amount of a antibody complex as described herein to the subject. The subject may be suffering from or at risk of, for example, Alzheimer's disease, Lewy body dementia, Down's syndrome, or cerebral amyloid angiopathy. The antibody complex may be administered systemically or peripherally or directly to the subject's central nervous system, e.g., intrathecally, intraventricularly, or intraparenchymally. In some embodiments, the antibody complex is delivered to the subject via an infusion device implanted in the patient.

BRIEF DESCRIPTION OF THE DRAWINGS

[14] **FIG. 1** is a schematic diagram of light and heavy chain expression vectors.

[15] **FIG. 2** provides heavy chain and light chain amino acid sequences of a murine anti-Aβ antibody, a deimmunized variant of the murine antibody, humanized grafted variant of the murine antibody, and composite human antibodies derived from the murine antibody.

[16] **FIG. 3-5** provide nucleotide sequences corresponding to the amino acid sequences of the composite human antibodies shown in **FIG. 2**.

[17] **FIG. 6** is a graph showing the frequency of HLA class II allotypes in the world population and a population studied.

[18] **FIGs. 7a-b** are graphs of results of MDT-2007 and chimeric antibodies tested in EPISCREEN™ (Antitope Ltd.) time course T cell assays using PBMC from 20 donors. Bulk cultures of PBMC incubated with test antibodies were sampled on days 5, 6, 7 and 8, and pulsed with 3H-Thymidine. Cells were harvested and incorporation of radioactivity measured by scintillation counting. Results for each triplicate sample were averaged and normalized by conversion to Stimulation Index (SI). The SI for each time point with each donor is shown above for (**a**) the chimeric antibody and (**b**) MDT-2007. The cut-off for determining positive responses with an SI ≥ 2 is highlighted by the horizontal line at 2.0 and significant responses ($p<0.05$ in a student's t-test) are indicated (*).

[19] **FIG. 8** is a graph of a comparison of immunogencity predicted using EPISCREEN™ (Antitope Ltd.) technology and immunogenicity observed in a clinical setting. Thirteen therapeutic proteins were tested for their relative risk of immunogenicity using EPISCREEN™ (Antitope Ltd.) technology. Results were plotted against the frequency of immunogenicity (antitherapeutic antibody responses) observed for each protein when used in the clinic (data sourced from PubMed). The line of regression and the correlation coefficient is shown.

[20] **FIGs. 9A-B** are images of MDT-2007 amyloid positive plaques in a section of the frontal cortex of an aged Rhesus monkey (**A**) and a section of a temporal cortex of an 84 year-old human female diagnosed with Alzheimer's Disease (**B**).

[21] **FIG. 10** is a schematic drawing of a side view of a representative infusion device showing selected internal components in block form.

[22] **FIG. 11** is a schematic drawing of a section of a brain and portions of a spinal cord showing cerebrospinal fluid flow.

[23] **FIG. 12** is a schematic drawing of a view of an infusion device and associated catheter implanted in a patient.

[24] **FIG. 13** is a schematic drawing of a view of a section of a patient showing an implanted infusion device and associated catheter implanted.

[25] **FIG. 14** is a schematic drawing of a view showing an implanted infusion device and associated catheter in the environment of a patient.

[26] **FIG. 15** is a schematic drawing of a view showing an injection port in the environment of a patient.

[27] **FIG. 16** is a schematic drawing of a side view of a representative system including an infusion device and a sensor, showing some internal components in block form.

[28] **FIG. 17** is a commassie blue stained SDS-PAGE gel of conjugated and unconjugated IgG anti-Aβ antibody and its $F(ab)_2$ fragment.

[29] **FIG. 18** is an image of a western immunoblot film depicting the ability of PSA-conjugated IgG anti-Aβ (relative to unconjugated) to bind amyloid beta ($A\beta_{40}$ and $A\beta_{42}$).

[30] **FIG. 19** is a graph showing the percentage of PSA-conjugated and unconjugated IgG anti-Aβ antibody and its $F(ab)_2$ fragment detected in mice 24 hours after i.p. injection.

[31] The drawings are not necessarily to scale. Like numbers used in the figures refer to like components, steps and the like. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number. In addition, the use of different numbers to refer to components is not intended to indicate that the different numbered components cannot be the same or similar.

DETAILED DESCRIPTION

[32] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration several specific embodiments of compositions of matter, apparatuses and methods. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense.

[33] Definitions:

[34] All scientific and technical terms used herein have meanings commonly used in the art unless otherwise specified. The definitions provided herein are to facilitate understanding of certain terms used frequently herein and are not meant to limit the scope of the present disclosure.

[35] As used in this specification and the appended claims, the singular forms “a”, “an”, and “the” encompass embodiments having plural referents, unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term “or” is generally employed in its sense including “and/or” unless the content clearly dictates otherwise.

[36] The term hybridoma describes the combination of a B cell that can recognize a particular antigen and a myeloma cell that lives indefinitely to make the hybridoma cell a kind of perpetual antibody-producing factory. The antibodies are therefore generated from animal cells, typically the mouse.

[37] In most cases, the patient’s immune system starts to recognize the mouse hybridoma cell as ‘foreign’ and will therefore destroy them. For this reason, the part of the mouse antibody gene responsible for recognizing a specific tumor antigen is combined with other parts from a human antibody gene. The product of this mouse-human antibody gene, called a "humanized" monoclonal antibody. This product looks enough like a normal human antibody to avoid being destroyed by the patient’s own immune system. This helps the

antibody to be effective for longer periods and avoids eliciting a potentially harmful immune response.

[38] As used herein, the terms "treat", "therapy", and the like mean alleviating, slowing the progression, preventing, attenuating, or curing the treated disease.

[39] As used herein, "disease", "disorder", "condition" and the like, as they relate to a subject's health, are used interchangeably and have meanings ascribed to each and all of such terms.

[40] As used herein, "subject" means a mammal to which an agent, such as an antibody, is administered for the purposes of treatment or investigation. Mammals include mice, rats, cats, guinea pigs, hamsters, dogs, monkeys, chimpanzees, and humans.

[41] As used herein, “isolated”, in the context of an antibody or nucleic acid molecule encoding an antibody, means the antibody or nucleic acid has been removed from its natural milieu or has been altered from its natural state. As such “isolated” does not necessarily reflect the extent to which the antibody or nucleic acid molecule has been purified. However, it will be understood that an antibody or nucleic acid molecule that has been purified to some degree is “isolated”. If the antibody or nucleic acid molecule does not exist in a natural milieu, i.e. it does not exist in nature, the molecule is “isolated” regardless of where it is present. By way of example, a humanized antibody that does not naturally exist in humans is “isolated” even when it is present in humans.

[42] A “conservative amino acid substitution” refers to substituting an amino acid of a polypeptide for another amino acid that is functionally similar. Such conservative amino acids may be substituted for each other in a polypeptide with a minimal disturbance to the structure or function of the polypeptide according to well-known techniques. The following five groups each contain amino acids that may be conservatively substituted for one another: Aliphatic: Glycine (G), Alanine (A), Valine (V), Leucine (L), Isoleucine (I); Aromatic: Phenylalanine (F), Tyrosine (T), Tryptophan (W); Sulfur-containing: Methionine (M), Cysteine (C); Basic: Arginine (R), Lysine (K), Histidine (H); Acidic: Aspartic acid (D), Glutamic acid (E), Asparagine (N), Glutamine (Q).

[43] <u>Sialic acid-containing molecules</u>

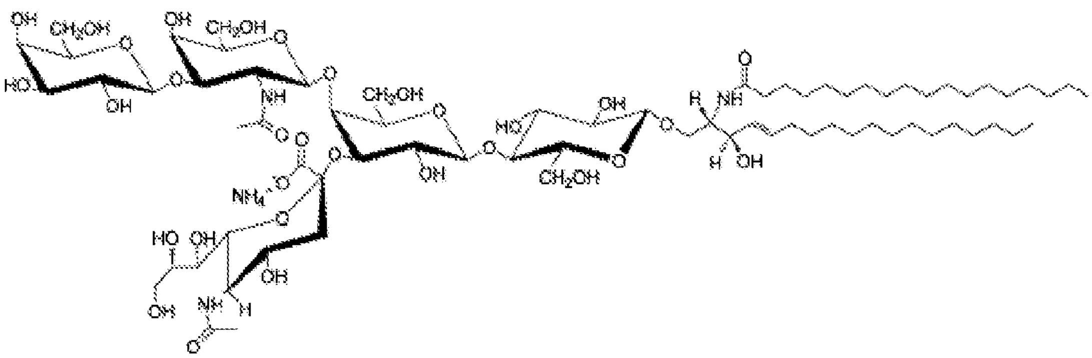
[44] One or more suitable sialic acid containing molecules may be associated with an anti-Aβ antibody to generate an antibody complex. The association may be through a covalent bond, a non-covalent bond, or other mechanism of interaction or association. In some embodiments, the sialic acid-containing molecule(s), such as polysialic acids, are attached to the antibody. While not intending to be limited by theory, it is believed that anti-Aβ antibodies associated with sialic acid-containing molecule(s) will generally be less immunogenic than the antibodies without associated sialic acid molecule(s). It is also believed, as evidenced by the results presented in Example 8 below, that antibodies associated with sialic acid-containing molecule(s) will take longer to clear from the body of a subject than antibodies without associated sialic acid-containing molecule(s).

[45] Examples of sialic acid-containing molecules that may be associated with an antibody include, for example, materials that include sialic acid, polysialic acid, sialic acid analogues and polysialic acid analogues (such analogues are materials containing synthetically modified sialic acid), phospholipids and polysaccharides containing sialic acid units (including those containing polysialic acid at a chain terminus), and the like. Various combinations of different sialic acid-containing molecules can be used if desired. In various embodiments, the sialic acid-containing molecule is oligomeric or polymeric and includes at least two sialic acid units, more preferably at least four sialic acid units, and even more preferably at least eight sialic acid units. Such materials are also referred to as "polysialic acids," or polymers of sialic acid whose degree of polymerization (DP) is preferably at least 2, more preferably at least 4, and even more preferably at least 8. There is no necessary limitation to the upper limit of the number of sialic acid units. Generally, such polymers could be as large as naturally occurring polysialic acids. In some embodiments, the number of sialic acid units is no greater than 1000, and in some embodiments no greater than 200.

[46] More specific examples of suituitable sialic acid-containing molecules that may be employed include, for example, capsular polysialic acid, sialic acid-containing gangliosides, colominic acid (i.e., a polysialic acid in which all sialic acid residues are linked in 2→8 fashion), and combinations thereof. Preferably, the sialic acid-containing molecules are anionic polymers of N-acetylneuraminic acid.

[47] Capsular polysialic acids are generally referred to by reference to the microorganisms that produce them. Suitable examples include Serogroup B capsular polysialic acid B from N. meningitidis or E. coli K1, Serogroup C capsular polysialic acid from N. meningitidis C, and polysialic acid from E. coli K92, which are abbreviated as PSB, PSC, and PSK92, respectively. See, for example, Gregoriadis et al., *FEBS Letter*, 315(3), January 1993, pp 271-76. Synthetic analogs of capsular polysialic acid are also suitable. One such analog is described as a twin-tailed, lipid-linked polysialic acid in Matthews et al., *Biopolymers*, 33, pp 453-7 (1993).

[48] Sialic acid-containing gangliosides are commercially available from sources such as Avanti Polar Lipids, Alabaster, AL. One such product has the structure



and is referred to by Product Number 860065; G_{M1} (Ovine); G_{M1} Ganglioside (Brain, Ovine-Ammonium Salt); or GalBeta1-3GalNAcBeta1-4(NeuAcAlpha2-3)GalBeta1-4GlcBeta1-1'-Cer (Brain, Ovine-Ammonium Salt). Mixtures of sialic acid-containing gangliosides are also commercially available.

[49] Any suitable method may be employed to associate a sialic acid-containing molecule(s) to an antibody. For example, sialic acid-containing molecule(s) may be conjugated to an antibody by modification (activation) of a terminal sialic acid moiety to structures that can interact with pendant groups of the antibody to generate complexes with an average of one or more sialic acid-containing molecule per antibody. Activation procedures include peroxidase oxidation of a non-reducing sialic acid moiety followed by interaction with ε-amino groups or the N-terminal amino acid of the antibody; e.g. in a manner similar to that described in Fernandes and Gregoriadis, 1996, Biochim. Biophys. Acta 1293, 92-96 or in Fernandes and Gregoriadis, 1997, Biochim. Biophys. Acta 1341, 26-34. Of course, any

other suitable known or future-developed technique may be employed. For example, an aldehyde on the terminal sialic acid unit may be generated (e.g., by reaction with sodium periodate), which may react with an amine of the antibody to yield an imine. This imine may be subsequently reduced by a reducing agent such as sodium borohydride to yield a hydrolytically stable secondary or tertiary amine.

[50] In various embodiments, an antibody complex includes at least one sialic acid-containing molecule at a suitable level to produce the desired result (e.g., improved bioavailability or reduced immunogenicity). More than one type of sialic acid-containing molecule can be used if desired.

[51] <u>Amyloid Beta</u>

[52] The antibody of an antibody complex as described above may be directed to amyloid beta. As used herein, "beta amyloid", "amyloid beta", "Abeta" and "Aβ" are used interchangeably. Aβ is peptide of about 39-43 amino acids that corresponds to a peptide formed *in vivo* upon cleavage of an amyloid beta precursor protein (APP or ABPP) by beta-secretase (at the N-terminal portion of Aβ) and gamma secretase (at the C-terminal portion of Aβ). See, e.g., Strooper and Annaert (2000; *J. Cell Sci.*, 113, 1857-1870) and Evin and Weidemann (2002; *Peptides*, 23, 1285-1297). The most common isoforms of Aβ are Aβ40 and Aβ42, 40 and 42 amino acids, respectively. Aβ42 is less common, but is thought to be more fibrillogenic than Aβ40. Effective antibodies may bind both Aβ40 and Aβ42, selectively bind Aβ42, bind all or some isoforms of Aβ, or the like.

[53] Of course it will be understood that antibodies may be directed towards any region of Aβ or selected regions of amyloid precursor protein. In various embodiments, antibodies are directed to an epitope at the N-terminal region of Aβ, e.g., the epitope contains amino acids within 5 amino acids of the N-terminal amino acid. In some embodiments, the epitope lies within amino acids 3-8 of an Aβ peptide and the antibody targets corresponds to amino acids 1-17. In some embodiments, antibodies are directed at the mid-terminal region of Aβ, e.g., the epitope corresponds to amino acids 17-24 of human Aβ. In various embodiments, antibodies are directed to an epitope at the C-terminal region of Aβ, e.g., the epitope corresponds to amino acids 24-40/42/43 of human Aβ or contains amino acids within 5 amino acids of the C-terminal amino acid. In some embodiments, antibodies are directed to intracellular contained Aβ. In numerous embodiments, antibodies are directed towards the extraceullar fraction of Aβ.

[54] The antibodies may be (i) anti-ADDL (Amyloid-beta derived diffusible ligands) antibodies as described in WO/2006/055178, (ii) bapineuzumab n-terminal (Elan &Wyeth), (iii) humanized m266 (LY2062430; Eli Lilly; e.g. as disclosed in US patent 7,195,761) which binds epitopes 16-24 in the mid section of Aβ, (iv) RN-1219 (PF04360365; Pfizer Rinat) which binds c-terminal epitope of Aβ, (v) fully humanized antibody R-1450 (Knappik et al., 2000; Hoffman-LaRoche/Morphosys), or (vi) the like. The antibodies used in accordance with the teachings provided herein may include non-specific antibodies such as IVIg Gammaguard (Baxter), F(ab')2 fragments (Wilcock et al., 2003), non-antibody Aβ42 binding compounds (Matsuoka et al., 2005), or the like.

[55] Aβ is the main constituent of amyloid plaques in brains of Alzheimer's disease patients. Similar plaques can also be found in some Lewy body dementia patients and Down's Syndrome patients. Similar plaques or Aβ aggregates are found in the cerebral vasculature of cerebral amyloid angiopathy patients. More recent reports describe the accumulation of both soluble and intracellular Aβ ahead of the extracellular amyloid plaques forming (in all of the conditions above) in earlier disease states. In various embodiments, the compositions or methods described herein may be employed to treat or study such diseases.

[56] It will be understood that clearance of soluble forms of Aβ or fibrils or plaques containing Aβ are contemplated. Current models of the physical state of Aβ are evolving. Over about the last 20 years, researchers have defined the soluble toxic species of Aβ according to multiple synonyms. The antibodies described herein may target any of the species defined in Masters and Beyreuther's review (2006), Brain, Nov; 129(Pt 11):2823-39. Targets include soluble dimmers, tetramers, dodecomers that may ultimately form oligomers, oligomers, amorphous aggregates, Abeta derived diffusible ligands (ADDLS), β-balls, β-Amy balls, globular Aβ oligomer, paranuclei, preamyloid, protofibril, spherocylindrical miscelles, spherical particles, spherical prefibrillar aggregates, and toxic Aβ soluble species.

[57] Antibodies

[58] Any anti-Aβ antibody may be employed in accordance with the teachings presented herein. Representative antibodies include polyclonal, monoclonal, and humanized antibodies.

[59] The term "antibody" is used in the broadest sense and specifically includes, for example, single anti-Aβ monoclonal antibodies (including agonist, antagonist, and neutralizing antibodies), anti-Aβ antibody compositions with polyepitopic specificity, single chain anti-anti-Aβ antibodies, and fragments of anti-Aβ antibodies (see below). The term "monoclonal antibody" as used herein refers to an antibody obtained from a population of substantially homogeneous antibodies, *i.e.*, the individual antibodies forming the population are identical except for possible naturally-occurring mutations that may be present in minor amounts. An antibody may include an immunoglobulin constant domain from any immunoglobulin, such as IgG-1, IgG-2, IgG-3, or IgG-4 subtypes, IgA (including IgA-1 and IgA-2), IgE, IgD or IgM.

[60] In various embodiments, an antibody includes an IgG-1 immunoglobulin. In many embodiments, an antibody includes an IgG-2 immunoglobulin. In some embodiments, an antibody includes an IgG-4. In numerous embodiments, an antibody includes a combination of various immunoglobulin isotypes, either to a specific epitope of anti-amyloid or broader spectrum IgGs. The structural and functional characteristics that distinguish the IgG subclasses affect the biologic activity of the antibody. For example, several of the IgG subclasses are activators of the classical complement system, although their effectiveness varies. Other distinguishing subclass factors reside in the antibodies ability to bind Fc receptors on phagocytic cells. Further distinctions between immunoglobulin subclasses are demonstrated by their differences in serum half life and pharmacokinetic profile. Tuning the biologic response and efficacy of the antibody to achieve efficacious neutralization or clearance of Aβ can be achieved via selection of the appropriate antibody subclass. For example, an IgG3 tends to be a more effective complement activator yet the function is not required, in and off itself, for efficacy of an anti-Aβ antibody. An IgG4 typically does not activate the classical complement system and, as such, is believed to have an advantage over an IgG3 anti-Aβ antibody in some situations. The IgG1 and IgG4 immunoglobulin represent balance in structural and

functional characteristics important for a safe and efficacious passive immunotherapy. Depending on the phase of the patient, either IgG1 or IgG4 anti-Aβ antibodies may be more efficacious. For example, neutralization without complement activation or phagocytosis may be more efficacious in the early phase of therapy where later phases may rely more on phagocytosis of the antigen/antibody complex. Furthermore, complement mediated phagocytosis may be desired when there is an excessive of antibody (Azeredo da Silveira et al., 2002). At higher doses of antibody there may be an increased density of antibody bound to plaques.

[61] In some embodiments, an antibody includes an IgM immunoglobulin. Antibodies having an IgM immunoglobulins may be better able to diffuse into tissue than similar antibodies having an IgG immunoglobulin.

[62] As used herein, an "antibody fragment" means a portion of an intact antibody, most typically the antigen binding or variable region of the intact antibody. Examples of antibody fragments include Fab, Fab', $F(ab')_2$, and Fv fragments; diaries; linear antibodies (Zapata et al., Protein Eng. 8 (10): 1057-1062 [1995]); and single-chain antibody molecules.

[63] Fv" is the minimum antibody fragment which contains a complete antigen-recognition and - binding site. This region consists of a dimer of one heavy-and one light-chain variable domain in tight, non-covalent association. It is in this configuration that the three complementary determining regions (CDRs) of each variable domain interact to define an antigen-binding site on the surface of the V_H-V_L dimer. Collectively, the six CDRs confer antigen-binding specificity to the antibody. However, even a single variable domain (or half of an Fv comprising only three CDRs specific for an antigen) has the ability to recognize and bind antigen, although at a lower affinity than the entire binding site.

[64] The Fab fragment also contains the constant domain of the light chain and the first constant domain (CH1) of the heavy chain. Fab fragments differ from Fab' fragments by the addition of a few residues at the carboxy terminus of the heavy chain CH1 domain including one or more cysteines from the antibody hinge region. $F(ab')_2$ antibody fragments originally were produced as pairs of Fab' fragments which have hinge cysteines between them. Other chemical couplings of antibody fragments are also known.

[65] The "light chains" of antibodies (immunoglobulins) from any vertebrate species can be assigned to one of two clearly distinct types, called kappa and lambda, based on the amino acid sequences of their constant domains.

[66] Depending on the amino acid sequence of the constant domain of their heavy chains, immunoglobulins can be assigned to different classes. There are five major classes of immunoglobulins: IgA, IgD, IgE, IgG, and IgM, and several of these may be further divided into subclasses (isotypes), e.g., IgG1, IgG2, IgG3, IgG4, IgA, and IgA2.

[67] "Single-chain Fv" or "sFv" antibody fragments include the V_H and V_L domains of antibody, wherein these domains are present in a single polypeptide chain. Preferably, the Fv polypeptide further comprises a polypeptide linker between the V_H and V_L domains, which enables the sFv to form the desired structure for antigen binding. For a review of sFv, see Pluckthun in The Pharmacology of Monoclonal Antibodies, vol. 113, Rosenburg and Moore eds., Springer-Verlag, New York, pp. 269-315 (1994).

[68] Where antibody fragments are used, the smallest inhibitory fragment that specifically binds to the binding domain of the target protein is preferred. For example, based upon the variable-region sequences of an antibody, peptide molecules can be designed that retain the ability to bind the target protein sequence. Such peptides can be synthesized chemically or produced by recombinant DNA technology. See, e.g., Marasco et al., Proc. Natl. Acad. Sci. USA, 90: 7889-7893 (1993).

[69] Any known or developed method for preparing antibodies may be used.

[70] A. Polyclonal Antibodies

[71] Polyclonal antibodies can be raised in a mammal, for example, by one or more injections of an immunizing agent and, if desired, an adjuvant. Typically, the immunizing agent or adjuvant will be injected in the mammal by multiple subcutaneous or intraperitoneal injections. The immunizing agent may include Aβ or fragment or fusion protein thereof. It may be useful to conjugate the immunizing agent to a protein known to be immunogenic in the mammal being immunized. Examples of such immunogenic proteins include but are not limited to keyhole limpet hemocyanin, serum albumin, bovine thyroglobulin, and soybean trypsin inhibitor. Examples of adjuvants which may be employed include Freund's

complete adjuvant and MPL-TDM adjuvant (monophosphoryl Lipid A, synthetic trehalose dicorynomycolate). The immunization protocol may be selected by one skilled in the art without undue experimentation.

[72] B. Monoclonal Antibodies

[73] Monoclonal antibodies may be prepared using hybridoma methods, such as those described by Kohler and Milstein, Nature, 256:495 (1975). In a hybridoma method, a mouse, hamster, or other appropriate host animal, is typically immunized with an immunizing agent to elicit lymphocytes that produce or are capable of producing antibodies that will specifically bind to the immunizing agent. Alternatively, the lymphocytes may be immunized in vitro.

[74] The immunizing agent will typically include Aβ or fragment or fusion protein thereof. Generally, either peripheral blood lymphocytes ("PBLs") are used if cells of human origin are desired, or spleen cells or lymph node cells are used if non-human mammalian sources are desired. The lymphocytes are then fused with an immortalized cell line using a suitable fusing agent, such as polyethylene glycol, to form a hybridoma cell, e.g. as described in Goding, Monoclonal Antibodies: Principles and Practice, Academic Press, (1986) pp. 59-103. Immortalized cell lines are usually transformed mammalian cells, particularly myeloma cells of rodent, bovine and human origin. Usually, rat or mouse myeloma cell lines are employed. The hybridoma cells may be cultured in a suitable culture medium that preferably contains one or more substances that inhibit the growth or survival of the unfused, immortalized cells. For example, if the parental cells lack the enzyme hypoxanthine guanine phosphoribosyl transferase (HGPRT or HPRT), the culture medium for the hybridomas typically will include hypoxanthine, aminopterin, and thymidine ("HAT medium"), which substances prevent the growth of HGPRT-deficient cells.

[75] Immortalized cell murine myeloma lines can be obtained, for example, from the Salk Institute Cell Distribution Center, San Diego, Calif. and the American Type Culture Collection, Manassas, Va. Human myeloma and mouse-human heteromyeloma cell lines also have been described for the production of human monoclonal antibodies See, e.g., Kozbor, J. Immunol., 133:3001 (1984); and Brodeur et al., Monoclonal Antibody

Production Techniques and Applications, Marcel Dekker, Inc., New York, (1987) pp. 51-63.

[76] The culture medium in which the hybridoma cells are cultured can then be assayed for the presence of monoclonal antibodies directed against Aβ. For example, the binding specificity of monoclonal antibodies produced by the hybridoma cells can be determined by immunoprecipitation or by an in vitro binding assay, such as radioimmunoassay (RIA) or enzyme-linked immunoabsorbent assay (ELISA). Such techniques and assays are known in the art. The binding affinity of the monoclonal antibody can, for example, be determined by the Scatchard analysis of Munson and Pollard, Anal. Biochem., 107:220 (1980).

[77] After the desired hybridoma cells are identified, the clones may be subcloned by limiting dilution procedures and grown by standard methods; e.g., as described in Goding, Monoclonal Antibodies: Principles and Practice, Academic Press, (1986) pp. 59-103. Suitable culture media for this purpose include, for example, Dulbecco's Modified Eagle's Medium and RPMI-1640 medium. Alternatively, the hybridoma cells may be grown *in vivo* as ascites in a mammal.

[78] The monoclonal antibodies secreted by the subclones may be isolated or purified from the culture medium or ascites fluid by conventional immunoglobulin purification procedures such as, for example, protein A-Sepharose, hydroxylapatite chromatography, gel electrophoresis, dialysis, or affinity chromatography.

[79] The monoclonal antibodies may also be made by recombinant DNA methods, such as those described in U.S. Pat. No. 4,816,567. DNA encoding the monoclonal antibodies can be readily isolated and sequenced using conventional procedures (e.g., by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of murine antibodies). The hybridoma cells serve as a preferred source of such DNA. Once isolated, the DNA may be placed into expression vectors, which are then transfected into host cells such as simian COS cells, Chinese hamster ovary (CHO) cells, or myeloma cells that do not otherwise produce immunoglobulin protein, to obtain the synthesis of monoclonal antibodies in the recombinant host cells. The DNA also may be modified, for example, by substituting the coding sequence for human heavy and light chain constant domains in place of the homologous murine sequences (see, e.g., U.S. Pat. No.

4,816,567) or by covalently joining to the immunoglobulin coding sequence all or part of the coding sequence for a non-immunoglobulin polypeptide. Such a non-immunoglobulin polypeptide can be substituted for the constant domains of an antibody, or can be substituted for the variable domains of one antigen-combining site of an antibody to create a chimeric bivalent antibody.

[80] The antibodies may be monovalent antibodies. Methods for preparing monovalent antibodies are well known in the art. For example, one method involves recombinant expression of immunoglobulin light chain and modified heavy chain. The heavy chain is truncated generally at any point in the Fc region so as to prevent heavy chain crosslinking. Alternatively, the relevant cysteine residues are substituted with another amino acid residue or are deleted so as to prevent crosslinking.

[81] *In vitro* methods are also suitable for preparing monovalent antibodies. Digestion of antibodies to produce fragments thereof, particularly, Fab fragments, can be accomplished using routine techniques known in the art. For example, antibodies may be digested with papain digestion to form $F(ab)'_2$ fragments.

[82] C. Human and Humanized Antibodies

[83] A non-human antibody, such as a mouse antibody, may be recognized by a human patient's immune system as 'foreign' and will therefore be destroyed and will elicit an undersirable immune response. For this reason, the part of the son-human antibody gene responsible for recognizing a specific antigen may be combined with other parts from a human antibody gene. The product of this mouse-human antibody gene, called a "humanized" antibody. This product looks enough like a normal human antibody to avoid being destroyed by the patient's own immune system. This helps the antibody to be effective for longer periods and avoids eliciting a potentially harmful immune response.

[84] Humanized forms of non-human (e.g., murine) antibodies may be chimeric immunoglobulins, immunoglobulin chains or fragments thereof (such as Fv, Fab, Fab', $F(ab')_2$ or other antigen-binding subsequences of antibodies) that contain minimal sequence derived from non-human immunoglobulin or that eliminate or reduce T-cell epitopes from the non-human antibodies. Humanized antibodies include human immunoglobulins (recipient antibody) in which residues from a complementary determining region (CDR) of the recipient are replaced by residues from a CDR of a non-human species (donor antibody) such as mouse, rat or rabbit having the desired specificity, affinity and capacity. In some instances, Fv framework residues of the human immunoglobulin are replaced by corresponding non-human residues. Humanized antibodies may also include residues which are found neither in the recipient antibody nor in the imported CDR or framework sequences. In general, the humanized antibody will include substantially all of at least one, and typically two, variable domains, in which all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin and all or substantially all of the FR regions are those of a human immunoglobulin consensus sequence. The humanized antibody may also include at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. See, e.g., Jones et al., Nature, 321:522-525 (1986); Riechmann et al., Nature, 332:323-329 (1988); and Presta, Curr. Op. Struct. Biol., 2:593-596 (1992).

[85] Methods for humanizing non-human antibodies are well known in the art. Generally, a humanized antibody has one or more amino acid residues introduced into it from a source which is non-human. These non-human amino acid residues are often referred to as "import" residues, which are typically taken from an "import" variable domain. Humanization can be essentially performed following the method of Winter and co-workers (see, e.g., Jones et al., Nature, 321:522-525 (1986); Riechmann et al., Nature, 332:323-327 (1988); and Verhoeyen et al., Science, 239:1534-1536 (1988)), by substituting rodent CDRs or CDR sequences for the corresponding sequences of a human antibody. Accordingly, such "humanized" antibodies are chimeric antibodies (U.S. Pat. No. 4,816,567), wherein substantially less than an intact human variable domain has been substituted by the corresponding sequence from a non-human species. In practice, humanized antibodies are typically human antibodies in which some CDR residues and possibly some FR residues are substituted by residues from analogous sites in rodent antibodies.

[86] Human antibodies can also be produced using various techniques known in the art, including phage display libraries. See, e.g., Hoogenboom and Winter, J. Mol. Biol., 227:381 (1991); and Marks et al., J. Mol. Biol., 222:581 (1991). Of course other techniques, such as those described by Cole et al. and Boerner et al,. are also available for the preparation of human monoclonal antibodies (Cole et al., Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, p. 77 (1985) and Boerner et al., J. Immunol., 147(1):86-95 (1991). Similarly, human antibodies can be made by introducing of human immunoglobulin loci into transgenic animals, e.g., mice in which the endogenous immunoglobulin genes have been partially or completely inactivated. Upon challenge, human antibody production is observed, which closely resembles that seen in humans in all respects, including gene rearrangement, assembly, and antibody repertoire. This approach is described, for example, in U.S. Pat. Nos. 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; 5,661,016, and in the following scientific publications: Marks et al., Bio/Technology 10, 779-783 (1992); Lonberg et al., Nature 368 856-859 (1994); Morrison, Nature 368, 812-13 (1994); Fishwild et al., Nature Biotechnology 14, 845-51 (1996); Neuberger, Nature Biotechnology 14, 826 (1996); Lonberg and Huszar, Intern. Rev. Immunol. 13 65-93 (1995).

[87] The antibodies may also be affinity matured using known selection or mutagenesis methods. Affinity matured antibodies may have an affinity that is five time or more than the starting antibody (generally murine, humanized or human) from which the matured antibody is prepared.

[88] Other methods for humanizing antibodies that may be employed include those described in, e.g., EO0629240, EP0983303, and WO2006/082406 (PCT/GB06/000355), where methods for germ-line humanization and reducing or eliminating T cell epitopes are discussed.

[89] In various embodiments, a humanized antibody includes a heavy chain variable region having an amino acid sequence of **SEQ ID NOs**: **42**, **44**, **46**, or **47-51** (see **FIG. 2**), or an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **42**, **44**, **46**, or **47-51**. In some embodiments where the antibody includes a heavy chain variable region having an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **42**, **44**, **46**, or **47-51**, one or more or all of the amino acid differences are conservative substitutions. The humanized antibody may further include a light chain variable region amino acid sequence of **SEQ ID NOs**: **43**, **45**, or **52-54** (see **FIG. 2**), or an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **43**, **45**, or **52-54**. In some embodiments where the antibody includes a light chain variable region having an amino acid sequence having 90% or greater, 95% or greater, 98% or greater, or 99% or greater sequence identity to **SEQ ID NOs**: **43**, **45**, or **52-54**, one or more or all of the amino acid differences are conservative substitutions. Any possible combination of such heavy chain and light chain amino acid sequences are contemplated. In some embodiments, a humanized antibody includes (i) a heavy chain variable region having an amino acid sequence of any of **SEQ ID NOs**: **47-51** and (ii) a light chain variable region having an amino acid sequence of any of **SEQ ID NOs: 52-54**.

[90] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:47** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**52**.

[91] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:48** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**54**.

[92] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:50** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**52**.

[93] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:51** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**52**.

[94] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:50** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**53**.

[95] In various embodiments, a humanized antibody includes (i) a variable heavy chain region comprising an amino acid sequence of **SEQ ID NO:51** and (ii) a variable light chain region comprising an amino acid sequence of **SEQ ID NO**:**53**.

[96] In various embodiments, a polynucleotide includes a sequence that encodes a humanized antibody as described herein. In some embodiments, the polynucleotide comprises a sequence selected from the group consisting of **SEQ ID NOs: 55**, **56**, **57**, **58**, **59**, **60**, **61**, and **62**.

[97] In various embodiments, an expression vector includes a polynucleotide as described above. In some embodiments, a cell contains such an expression vector. In numerous embodiments, the expression of the expression vector results in production of an antibody as described above.

[98] Humanized antibodies, as described herein, may be prepared according to any known or developed method. Typically, the humanized antibodies will be expressed from expression vectors transfected or transformed into cells; e.g., as described the Examples provided below.

[99] D. Cloning and expression of antibodies

[100] Host cells may be transfected or transformed with cloning vectors or expression vectors for antibody production and cultured in conventional nutrient media modified as appropriate for inducing promoters, selecting transformants, or amplifying the genes encoding the desired sequences. The culture conditions, such as media, temperature, pH and the like, can be selected by the skilled artisan without undue experimentation. In general, principles, protocols, and practical techniques for maximizing the productivity of cell cultures can be found in Mammalian Cell Biotechnology: a Practical Anproach, M. Butler, ed. (IRL Press, 1991) and Molecular Cloning, A Laboratory Manual, 3rd edition, vols 1-3, eds. Sambrook and Russel (2001) Cold Spring Harbor Laboratory Press.

[101] Methods of eukaryotic cell transfection and prokaryotic cell transformation are known to those of ordinarily skill in the art and include, for example, $CaCl_2$, $CaPO_4$, liposome-mediated and electroporation. Depending on the host cell used, transformation is performed using standard techniques appropriate to such cells. For example, calcium treatment employing calcium chloride, as described Molecular Cloning, A Laboratory Manual, 3rd edition, vols 1-3, eds. Sambrook and Russel (2001) Cold Spring Harbor Laboratory Press, or electroporation may be used for prokaryotes. For mammalian cells that do not contain

cell walls, the calcium phosphate precipitation method of Graham and van der Eb, Virology, 52:456-457 (1978) may be employed. General aspects of mammalian cell host system transfections have been described in, e.g., U.S. Pat. No. 4,399,216. Transformations into yeast are typically carried out according to the method of Van Solingen et al., J. Bact., 130:946 (1977) or Hsiao et al., Proc. Natl. Acad. Sci. (USA), 76:3829 (1979). However, other methods for introducing DNA into cells, such as by nuclear microinjection, electroporation, bacterial protoplast fusion with intact cells, or polycations, e.g., polybrene, polyornithine, may also be used. For various techniques for transforming mammalian cells, see Keown et al., Methods in Enzymology, 185:527-537 (1990) and Mansour et al., Nature, 336:348-352 (1988).

[102] Suitable host cells for cloning the DNA in the vectors herein include prokaryote, yeast, or higher eukaryote cells. Suitable prokaryotes include eubacteria, such as Gram-negative or Gram-positive organisms, for example, Enterobacteriaceae such as E. coli. Various E. coli strains are publicly available, such as E. coli K12 strain MM294 (ATCC 31,446); E. coli X1776 (ATCC 31,537); E. coli strain W3110 (ATCC 27,325) and K5 772 (ATCC 53,635). Other suitable prokaryotic host cells include Enterobacteriaceae such as Escherichia, e.g., E. coli, Enterobacter, Erwinia, Klebsiella, Proteus, Salmonella, e.g., Salmonella typhimurium, Serratia, e.g., Serratia marcescans, and Shigella, as well as Bacilli such as B. subtilis and B. licheniformis (e.g., B. licheniformis 41P disclosed in DD 266,710 published Apr. 12, 1989), Pseudomonas such as P. aeruginosa, and Streptomyces. Alternatively or in addition, in vitro methods of cloning, e.g., PCR or other nucleic acid polymerase reactions are suitable.

[103] Suitable host cells for the expression of glycosylated humanized antibodies include those derived from multicellular organisms. Examples of invertebrate cells include insect cells such as Drosophila S2 and Spodoptera Sf9, as well as plant cells. Examples of useful mammalian host cell lines include Chinese hamster ovary (CHO) and COS cells. More specific examples include monkey kidney CV1 line transformed by SV40 (COS-7, ATCC CRL 1651); human embryonic kidney line (293 or 293 cells subcloned for growth in suspension culture, Graham et al., J. Gen Virol., 36:59 (1977)); Chinese hamster ovary cells/-DHFP (CHO, Urlaub and Chasin, Proc. Natl. Acad. Sci. USA, 77:4216 (1980)); mouse sertoli cells (TM4, Mather, Biol. Reprod., 23:243-251 (1980)); human lung cells (W138, ATCC CCL 75); human liver cells (Hep G2, HB 8065); and mouse mammary tumor (MMT 060562, ATCC CCL51). The selection of the appropriate host cell is within the routine ability skill in the art.

[104] The nucleic acid (e.g., cDNA or genomic DNA) encoding a humanized antibody (or portion thereof) may be inserted into a replicable vector for cloning (amplification of the DNA) or for expression. Various vectors are publicly available. The vector may, for example, be in the form of a plasmid, cosmid, viral particle, or phage. The appropriate nucleic acid sequence may be inserted into the vector by a variety of procedures. In general, DNA is inserted into an appropriate restriction endonuclease site(s) using techniques known in the art. Vector components generally include, but are not limited to, one or more of a signal sequence, an origin of replication, one or more marker genes, an enhancer element, a promoter, and a transcription termination sequence. Construction of suitable vectors containing one or more of these components employs standard ligation techniques which are known to those of skill in the art.

[105] The antibody (or portion thereof) may be produced recombinantly not only directly, but also as a fusion polypeptide with a heterologous polypeptide, which may be a signal sequence or other polypeptide having a specific cleavage site at the N-terminus of the mature protein or polypeptide. In general, the signal sequence may be a component of the vector, or it may be a part of the humanized antibody (or portion thereof)-encoding DNA that is inserted into the vector.

[106] Expression vectors or cloning vectors may incude a nucleic acid sequence that enables the vector to replicate in one or more selected host cells. Such sequences are well known for a variety of bacteria, yeast, and viruses. The origin of replication from the plasmid pBR322 is suitable for most Gram-negative bacteria, the 2μ plasmid origin is suitable for yeast, and various viral origins (SV40, polyoma, adenovirus, VSV or BPV) are useful for cloning vectors in mammalian cells.

[107] Expression and cloning vectors may contain a selection gene, also termed a selectable marker. Typical selection genes encode proteins that (a) confer resistance to antibiotics or other toxins, e.g., ampicillin, neomycin, methotrexate, or tetracycline, (b) complement auxotrophic deficiencies, or (c) supply critical nutrients not available from complex media, e.g., the gene encoding D-alanine racemase for Bacilli.

[108] Expression and cloning vectors usually contain a promoter operably linked to the humanized antibody (or portion thereof)-encoding nucleic acid sequence to direct mRNA synthesis. Promoters recognized by a variety of potential host cells are well known. Promoters suitable for use with prokaryotic hosts include the β-lactamase and lactose promoter systems [Chang et al., Nature, 275:615 (1978); Goeddel et al., Nature, 281:544 (1979)], alkaline phosphatase, a tryptophan (trp) promoter system [Goeddel, Nucleic Acids Res., 8:4057 (1980); EP 36,776], and hybrid promoters such as the tac promoter [deBoer et al., Proc. Natl. Acad. Sci. USA, 80:21-25 (1983)]. Promoters for use in bacterial systems also will contain a Shine-Dalgamo (S.D.) sequence operably linked to the DNA encoding HCN or Kir2.1 channel.

[109] An antibody (or portion thereof) transcription from vectors in mammalian host cells is controlled, for example, by promoters obtained from the genomes of viruses such as polyoma virus, fowlpox virus (UK 2,211,504 published Jul. 5, 1989), adenovirus (such as Adenovirus 2), bovine papilloma virus, avian sarcoma virus, cytomegalovirus, a retrovirus, hepatitis-B virus and Simian Virus 40 (SV40), from heterologous mammalian promoters, e.g., the actin promoter or an immunoglobulin promoter, and from heat-shock promoters, provided such promoters are compatible with the host cell systems.

[110] Transcription of a DNA encoding the antibody by higher eukaryotes may be increased by inserting an enhancer sequence into the vector. Enhancers are cis-acting elements of DNA, usually about from 10 to 300 bp, that act on a promoter to increase its transcription. Many enhancer sequences are now known from mammalian genes (globin, elastase, albumin, α-fetoprotein, and insulin). Typically, however, one will use an enhancer from a eukaryotic cell virus. Examples include the SV40 enhancer on the late side of the replication origin (bp 100-270), the cytomegalovirus early promoter enhancer, the polyoma enhancer on the late side of the replication origin, and adenovirus enhancers. The enhancer may be spliced into the vector at a position 5' or 3' to the humanized antibody (or portion thereof) coding sequence, but is preferably located at a site 5' from the promoter.

[111] Expression vectors used in eukaryotic host cells (yeast, fungi, insect, plant, animal, human, or nucleated cells from other multicellular organisms) will also contain sequences necessary for the termination of transcription and for stabilizing the mRNA. Such sequences are

commonly available from the 5' and, occasionally 3', untranslated regions of eukaryotic or viral DNAs or cDNAs. These regions contain nucleotide segments transcribed as polyadenylated fragments in the untranslated portion of the mRNA encoding a humanized antibody (or portion thereof).

[112] For example, a viral vector, such as an adeno-associated viral (AAV) vector may be operatively linked components of control elements. For example, a typical vector includes a transcriptional initiation region, a nucleotide sequence of the protein to be expressed, and a transcriptional termination region. Typically, such an operatively linked construct will be flanked at its 5 and 3 regions with AAV ITR sequences, which are viral cis elements. The control sequences can often be provided from promoters derived from viruses such as, polyoma, Adenovirus 2, cytomegalovirus, and Simian Virus 40. Viral regulatory sequences can be chosen to achieve a high level of expression in a variety of cells. Alternatively, ubiquitously expressing promoters, such as the early cytomegalovirus promoter can be utilized to accomplish expression in any cell type. A third alternative is the use of promoters that drive tissue specific expression. This approach is particularly useful where expression of the desired protein in non-target tissue may have deleterious effects. Thus, according to various embodiments, the vector contains the proximal human brain natriuretic brain (hBNP) promoter that functions as a cardiac-specific promoter. For details on construction of such a vector see LaPointe et al., "Left Ventricular Targeting of Reporter Gene Expression In Vivo by Human BNP Promoter in an Adenoviral Vector," Am. J. Physiol. Heart Circ. Physiol., 283:H1439-45 (2002).

[113] Expression vectors containing DNA encoding a humanized antibody (or portion thereof) may be administered *in vivo* in any known or future developed manner. In various embodiments, the expression vectors are packaged into viruses, such as adenoviruses, and are delivered in proximity to targeted cells, tissue or organs. In varous embodiments, the expression vectors are packaged into adenoviruses, such as helper-dependent adeno virus (HDAd) or adeno-assocated virus pseudo-type 9 (AAV2/9). HDAd virus packaging typically illicits less of an immunogenic response *in vivo* compared to some other adenoviruses and thus allows for longer term expression. AAV2/9 packaging can result in cardiac tropism as well as a prolonged expression time frame.

[114] Alternatively, non-viral delivery systems are employed. For example, liposomes, DNA complexes, plasmids, liposome complexes, naked DNA, DNA-coated particles, or polymer based systems may be used to deliver the desired sequence to the cells. The above-mentioned delivery systems and protocols therefore can be found in Gene Targeting Protocols, Kmeic 2ed., pages 1-35 (2002) and Gene Transfer and Expression Protocols, Vol. 7, Murray ed., Pages 81-89 (1991).

[115] An expression vector including a polynucleotide encoding an antibody (or portion thereof) can be delivered into a cell by, for example, transfection or transduction procedures. Transfection and transduction refer to the acquisition by a cell of new genetic material by incorporation of added nucleic acid molecules. Transfection can occur by physical or chemical methods. Many transfection techniques are known to those of ordinary skill in the art including, without limitation, calcium phosphate DNA co-precipitation, DEAE-dextrin DNA transfection, electroporation, naked plasmid adsorption, and cationic liposome-mediated transfection. Transduction refers to the process of transferring nucleic acid into a cell using a DNA or RNA virus. Suitable viral vectors for use as transducing agents include, but are not limited to, retroviral vectors, adeno associated viral vectors, vaccinia viruses, an Semliki Foret virus vectors.

[116] Separate vectors may be employed to express a light chain and a heavy chain. Of course, nucleic acid encoding a heavy chain and a light chain may be introduced into a single vector.

[117] Compositions

[118] Antibody complexes (antibodies associated with sialic acid-containing molecule(s)) can be administered for the treatment or study of various disorders in the form of pharmaceutical compositions. Pharmaceutical compositions may be used for the purposes of treatment or for investigation.

[119] Antibody complexes as described herein can be administered as pharmaceutical compositions of the antibody complex and a variety of other pharmaceutically acceptable components. See Remington's Pharmaceutical Science (15th ed., Mack Publishing Company, Easton, Pa. (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 adversely affect the biological activity of the antibody. 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.

[120] 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™ (GE Healthcare Bio-Sciences Ltd.), agarose, cellulose, and the like), polymeric amino acids, amino acid copolymers, and lipid aggregates (such as oil droplets or liposomes).

[121] Pharmaceutical compositions may be injectable compositions. Injectable compositions include solutions, suspensions, dispersions, and the like. Injectable solutions, suspensions, dispersions, and the like may be formulated according to techniques well-known in the art (see, for example, Remington's Pharmaceutical Sciences, Chapter 43, 14th Ed., Mack Publishing Co., Easton, Pa.), using suitable dispersing or wetting and suspending agents, such as sterile oils, including synthetic mono- or diglycerides, and fatty acids, including oleic acid.

[122] Injectable compositions that include an anti-Aβ antibody/sialic acid-containing molecule complex may be prepared in water, saline, isotonic saline, phosphate-buffered saline, citrate-buffered saline, and the like and may optionally mixed with a nontoxic surfactant. Dispersions may also be prepared in glycerol, liquid polyethylene, glycols, DNA, vegetable oils, triacetin, and the like and mixtures thereof. Under ordinary conditions of storage and use, these preparations may contain a preservative to prevent the growth of microorganisms. Pharmaceutical dosage forms suitable for injection or infusion include sterile, aqueous solutions or dispersions or sterile powders comprising an active ingredient which powders are adapted for the extemporaneous preparation of sterile injectable or infusible solutions or dispersions. Preferably, the ultimate dosage form is a sterile fluid and stable under the conditions of manufacture and storage. A liquid carrier or vehicle of the solution, suspension or dispersion may be a solvent or liquid dispersion medium comprising, for example, water, ethanol, a polyol such as glycerol, propylene glycol, or liquid polyethylene glycols and the like, vegetable oils, nontoxic glyceryl esters, and suitable mixtures thereof. Proper fluidity of solutions, suspensions or dispersions may be maintained, for example, by the formation of liposomes, by the maintenance of the desired particle size, in the case of dispersion, or by the use of nontoxic surfactants. The prevention of the action of microorganisms can be accomplished by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. Isotonic agents such as sugars, buffers, or sodium chloride may be included. Prolonged absorption of the injectable compositions can be brought about by the inclusion in the composition of agents delaying absorption--for example, aluminum monosterate hydrogels and gelatin. Solubility enhancers may be added.

[123] Sterile injectable compositions may be prepared by incorporating an anti-Aβ antibody complex in the desired amount in the appropriate solvent with various other ingredients, e.g. as enumerated above, and followed by sterilization, as desired, by, for example filter sterilization. In the case of sterile powders for the preparation of sterile injectable solutions, methods of preparation include vacuum drying and freeze-drying techniques, which yield a powder of the active ingredient plus any additional desired ingredient present in a previously sterile-filtered solution. Any suitable sterilization process may be employes, such as filter sterilization, e.g. 0.22 micron filter or nanofiltration, gamma or electron beam sterilization, or pused white light. Other suitable sterilization processes include UtiSter (Pegasus Biologics, Irvinie CA) and those described in, e.g., U.S. Patent No. 6,946,098 and U.S. Patent No. 5,730,933.

[124] In various embodiments, the final solution is adjusted to have a pH between about 4 and about 9, between about 5 and about 7, between about 5.5 and about 6.5, or about 6. The pH of the composition may be adjusted with a pharmacologically acceptable acid, base or buffer. Hydrochloric acid is an example of a suitable acid, and sodium hydroxide is an example of a suitable base. The hydrochloric acid or sodium hydroxide may be in any suitable form, such as a 1N solution

[125] A resultant injectable solution preferably contains an amount of one or more anti-Aβ antibody complexes effective to treat a disease associated with increase or aberrant soluble Aβ or to allow meaningful study of a subject to which the solution is injected. In various embodiments for direct CNS infusion, an anti-Aβ antibody complex is present in an injectable composition at a concentration between about 0.0001 mg/ml and about 50 mg/ml. In various embodiments, an anti-Aβ antibody complex is present in an injectable composition at a concentration between about .01 mg/mL and about 10 mg/mL. In various embodiments, an anti-Aβ antibody complex is present in an injectable composition at a concentration of about 1 mg/mL.

[126] Of course, anti-Aβ antibody complexes may be administered to the CNS 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.

[127] The formulations discussed above or other formulations containing an anti-Aβ antibody complex may be administered to a subject via any acceptable route. In various embodiments, a formulation comprising an antibody complex including an antibody capable of binding Aβ is chronically administered directly to the CNS of a subject. By chronically, it is meant over the course or days, weeks or months. In some circumstances, chronic administration may occur at various times or continuously over the life of the patient after therapy is initiated, or until the patient no longer presents symptoms of the treated disease state. As used herein, "direct administration to the CNS", or the like, means delivery of an agent via a delivery region infusion portion of a catheter, where the delivery portion of the catheter is located within the CNS. Example routes of direct CNS administration include intraparenchymal, intrathecal, intracerebroventricular, epidural, or the like. Non-limiting examples of catheters include cannulas, needles, tubes, and the like. A delivery portion of a catheter is typically located at or near a distal end portion of a catheter and may include an opening in fluid communication with a lumen of a catheter.

[128] In some embodiments, formulations containing an anti-Aβ antibody complex are administered to the CNS via an implantable infusion device, for example, as described below with regard to **FIGs. 10-16** and associated text under the heading "delivery device". Suitable systems and conditions for delivering anti-Aβ antibodies via an implantable infusion device are described in, e.g., U.S. Patent Application No. 12/120,269, filed May 14, 2008, which application is hereby incorporated herein by reference in its entirety to the extent that it does not conflict with the present disclosure.

[129] An injectable composition including an anti-Aβ antibody complex may be delivered at any suitable rate. For chronic delivery to the CNS, the composition may be delivered at a rate of 0.01-15 ml/day, 0.01-5 ml/day, or 0.01-1 ml/day. It will be understood that the concentration of the anti-Aβ antibody complex in the composition may be adjusted, based on the delivery rate, to achieve a desired daily dose. The rate of delivery may be constant or may be variable. In various embodiments, delivery includes periods of increased delivery rate (e.g., pulsed boluses) on top of a constant lower rate. Such pulsed boluses may readily be achieved with a programmable infusion device such as the SYNCHROMED II® (Medtronic, Inc.) infusion device. Such pulsed bolus administration may result in improved distribution of the delivered antibody relative to constant rate delivery due to increased convection. In some embodiments, the antibody complex is delivered for a period of time, the delivery is then halted, and then resumed. For example, the antibody complex may be delivered for one hour to one week, delivery may then be halted for one hour to one week, and so on. Such a dosing scheme may serve to prolong the delivery life of the antibody, as the half life of the delivered antibody complex may be considerably shorter than the half life of an antibody complex housed in a reservoir of an infusion device.

[130] In some embodiments, the mode of delivery may be altered during the course of treatment. For example, the antibody complex may be delivered i.c.v. at one stage of treatment and delivered intraparenchymally (i.p.a) at another stage of treatment, as conditions warrant. For example, if it is desired to obtain microglial activation to clear of Aβ, i.p.a. administration may be desired. If clearance via a CSF sink is desired, i.c.v. administration may be desired. Alternatively, or in addition, an antibody complex may be delivered i.c.v. and i.p.a at the same time. Regardless of whether the route of administration is altered or if delivery is accomplished simultaneously via two routes, it may be desirable to implant a delivery region of a catheter intraparenchymally and implant a delivery region of the same (e.g., split catheter) or different catheter in the CSF at the time of initial implant.

[131] <u>Methods</u>

[132] Administering an antibody complex including an antibody capable of binding Aβ in the CNS of a subject as described herein or according to any other known or developed technique may be used to treat, prevent, or study a disease associated with increased or aberrant soluble Aβ, amyloid fibrils or amyloid plaques. Examples of disease associated with increased or aberrant soluble Aβ, amyloid fibrils or amyloid plaques include Alzheimer's disease (AD), cerebral amyloid angiopathy (CAA), Lewy body dementia, and Down's Syndrome (DS). The antibody complexes may also be used in animal models of such disease states.

[133] Any amount of antibody complex having antibody effective to bind Aβ, whether soluble, in fibrils, plaques, or the like may be employed. In general, a daily dose of between about 0.0001 and about 1 mg of the antibody per kg of the subject's body weight will be effective. In various embodiments, daily doses of between about 0.001 and about 1, between about 0.01 and about 0.1, or between about 0.1 and about 1 mg of the antibody per kg of the subject's body weight are administered to the subject's CNS. The above daily doses should be generally effective for i.c.v. delivery to a lateral ventrical of the subject. For intrathecal delivery, increased dosages may be warranted. For example, daily dosages may be increased by about 20% relative to i.c.v. Any other suitable modification in dosing based on route of administration in comparison to i.c.v. may be employed. Of course, the antibody need not be administered daily, but may be administered only once, once a week, once a month, every other day, or according to any other suitable regimen.

[134] In various embodiments a method includes identifying a subject suffering from or at risk of AD and chronically delivering to the CNS of the subject an antibody complex including an antibody directed to Aβ. Those at risk of AD include those of advancing age, family history of the disease, mutations in APP or related genes, having heart disease risk factors, having stress or high levels of anxiety. Identification of those suffering from or at risk of AD can be readily accomplished by a physician. Diagnosis may be based on mental, psychiatric and neuropyschological assessments, blood tests, brain imaging (PET, MRI, CT scan), urine tests, tests on the cerebrospinal fluid obtained through lumbar puncture, or the like.

[135] In various embodiments a method includes identifying a patient suffering from or at risk of CAA and chronically delivering to the CNS of the patient an antibody complex including an antibody directed to Aβ. Symptoms of CAA include weakness or paralysis of the limbs, difficulty speaking, loss of sensation or balance, or even coma. If blood leaks out to the sensitive tissue around the brain, it can cause a sudden and severe headache. Other symptoms sometimes caused by irritation of the surrounding brain are seizures (convulsions) or short spells of temporary neurologic symptoms such as tingling or weakness in the limbs or face. CAA patients can be identified by, e.g., examination of an evacuated hematoma or brain biopsy specimen, the frequency of APOE ε2 or ε4 alleles, with clinical or radiographic (MRI and CT scans) grounds according the Boston Criteria (Knudsen et al., 2001, Neurology;56:537-539), or the like. Those at risk of CAA include those of advancing age, those having the APOE genotype, and those having other risk factors associated with AD.

[136] In various embodiments a method includes identifying a patient suffering from or at risk of Down Syndrome and chronically delivering to the CNS of the patient an antibody complex including and antibody directed to Aβ. A newborn with Down syndrome can be identified at birth by a physician's physical exam. The diagnosis may be confirmed through kariotyping. Multiple screening tests may be used to test or diagnosis a patient prior to birth (biomarkers, nuchal translucency, amniocentesis, etc.). A Down's syndrome patient may be diagnosis with AD using diagnostic criteria relevant for AD.

[137] In various embodiments a method includes identifying a patient suffering from or at risk of Lewy body dementia and chronically delivering to the CNS of the patient an antibody complex including an antibody directed to Aβ. Those suffering from or at risk of Lewy body dementia can be identified by mental, psychiatric or neuropyschological assessments, blood tests, brain imaging (PET, MRI, CT scan), urine tests, tests on the cerebrospinal fluid obtained through lumbar puncture, or the like. Those at risk of Lewy body dementia include those of advancing age.

[138] In various embodiments, cerebral plaques may be cleared or prevented from forming by administering anti-Aβ antibody complexes to a subject's CNS. It will be understood that achieving any level of clearing of a plaque or plaques will constitute clearing of the plaque or plaques. It will be further understood that achieving any level of prevention of formation of a plaque or plaques will constitute preventing formation of the plaque or plaques.

Accordingly, in various embodiments, methods for clearing plaques include delivering, to a subject in need thereof, an amount of an anti-Aβ antibody complex effective in clearing the plaques. In various embodiments, methods for preventing the formation of plaques include delivering, to a subject in need thereof, an amount of an anti-Aβ antibody complex effective in preventing the formation the plaques. The methods may further include clearing or preventing parenchymal amyloid plaques or soluble forms of Aβ. The methods may further include improving cognitive aspects of the subject.

[139] In various embodiments, cognitive abilities of a subject are improved by administering an anti-Aβ antibody complex to a subject's CNS.

[140] In various embodiments, parenchymal amyloid plaques or soluble forms of Aβ are cleared in a subject by administering an anti-Aβ antibody complex to a subject's CNS.

[141] The ability of a therapy described herein to treat a disease may be evaluated through medical examination, e.g. as discussed above, or by diagnostic or other tests. In various embodiments, a method as described in WO 2006/107814 (Bateman et al.) is performed. For example, a subject may be administered radiolabeled leucine. Samples, such as plasma or CSF, may then be obtained to quantify the labeled-to-unlabeled leucine in, for example, amyloid beta or other key disease related biomarkers, to determine the production and clearance rate of such proteins or polypeptides.

[142] Clearing of, or formation of, amyloid beta can be evaluated *in vivo* by structural or functional neuro-imaging techniques. For example, diffusion tensor MRI (reviewed in Parente et al., 2008; Chua et al., 2008), PET imaging with the Aβ binding compound, Pittsburgh Compound B (PiB, Klunk et al., 2004; Fagan et al., 2006; Fagan et al 2007) or other SPECT based imaging of fibrillar Aβ structures and measurement of CSF levels of Aβ42 or tau may be employed. Distribution of vascular Aβ may be evaluated using differential interpretation of PET imaging of PiB (Johnson et al., 2007). Additionally, a cerebral microhemorrahage may be recognized by on gradient-echo or T-2 weighted MRI sequences (Viswanathan and Chabriat, 2006).

[143] Similarly, detection of hemorrhages of the cerebral vasculature can be evaluated by imaging techniques, clinical evaluation, or the like. Spontaneous intracerebral hemorrhage (ICH) usually results in a focal neurologic deficit and is easily diagnosed on clinical and radiographic grounds (computed tomography (CT) scan, T-2 weighted MRI). Cerebral microhemorrhage results from underlying small vessel pathologies such as hypertensive vasculpathy or CAA. Cerebral microhemorrhages, best visualized by MRI, result from rupture of small blood vessels. The MRI diagnosis can be variable as described by Orgagozo et al., 2003 (Subacute meningoencephalitis in a subset of patients with AD after Aβ42 immunization-Elan Trial). For instance, patients showing signs and symptoms of aseptic meningoencephalitis MRIs showed only meningeal enhancement, whereas others had meningeal thickening, white matter lesions, with or without enhancing or edema, and a majority had posterior cerebral cortical or cerebellar lesions. Other potential diagnostics include changes in intracranial pressure, which may be detected by specific MRI techniques (Glick, et al., 2006, Alperin) or other standard techniques as described in Method of detecting brain microhemmorhage (United States Patent No. 5,951,476).

[144] In various embodiments, an antibody complex is used to detect Aβ; e.g., in a diagnostic assay or as part of a diagnostic kit. For example, the antibody complex may be used to determine the ability of a therapeutic agent or putative therapeutic agent to affect processing of APP to produce soluble Aβ. In such uses, it may be desirable for the antibody complex to be labeled; e.g., with a fluorescent tag, a paramagnetic tag, or the like.

[145] <u>Delivery Device</u>

[146] In various embodiments, formulations containing an anti-Aβ antibody complexes are administered to the CNS via an infusion device. A system including an infusion device may be used to deliver a composition containing an anti-Aβ antibody complex to the CNS of a subject. The system may further includes a catheter operably couplable to the infusion device. The infusion device may include a drive mechanism. Non-limiting examples of drive mechanisms include peristaltic pumps, osmotic pumps, piston pumps, pressurized gas mechanisms, and the like. Devices including such drive mechanisms may be fixed-rate pumps, variable rate pumps, selectable rate pumps, programmable pumps and the like. Each of the aforementioned infusion systems contain a reservoir for housing a fluid composition containing the anti-Aβ antibody. The catheter includes one or more delivery regions, through which the fluid may be delivered to one or more target regions of the subject. The infusion device may be implantable or may be placed external to the subject.

[147] An infusion device **30** according to various embodiments is shown in **FIG. 10** and includes a reservoir **12** for housing a composition and a drive mechanism **40** operably coupled to the reservoir **12**. The catheter **38** shown in **FIG. 11** has a proximal end **35** coupled to the therapy delivery device **30** and a distal end **39** configured to be implanted in a target location of a subject. Between the proximal end **35** and distal end **39** or at the distal end **39**, the catheter **38** has one or more delivery regions (not shown), such as openings, through which the composition may be delivered. The infusion device **30** may have a port **34** into which a hypodermic needle can be inserted to inject a composition into reservoir **12**. The infusion device **30** may have a catheter port **37**, to which the proximal end **35** of catheter **38** may be coupled. The catheter port **37** may be operably coupled to reservoir **12**. A connector **14**, such as a barbed connector or sutureless connector, may be used to couple the catheter **38** to the catheter port **37** of the infusion device **30**. The infusion device **30** may be operated to discharge a predetermined dosage of the pumped fluid into a target region of a subject. The infusion device **30** may contain a microprocessor **42** or similar device that can be programmed to control the amount of fluid delivery. The programming may be accomplished with an external programmer/control unit via telemetry. A controlled amount of fluid may be delivered over a specified time period. With the use of a programmable infusion device **30**, dosage regimens may be programmed and tailored for a particular patient. Additionally, different therapeutic dosages can be programmed for different combinations of fluid comprising therapeutics. Those skilled in the art will recognize that a programmable infusion device **30** allows for starting conservatively with lower doses and adjusting to a more aggressive dosing scheme, if warranted, based on safety and efficacy factors.

[148] While not shown in **FIG. 10**, device **30** may include a catheter access port to allow for direct delivery of a composition including an anti-Aβ antibody complex via catheter **38**. Also not shown are other components, such as one-way valves, that may be included at one or more locations along the fluid flow path of the device **30**. It will be understood that the components and the configuration of the components depicted in **FIG. 10** may be readily

modified to achieve a suitable infusion device **30** for delivering an injectable composition including a humanized anti-Aβ antibody complex.

[149] According to various embodiments, a composition comprising a humanized anti-Aβ antibody complex may be delivered directly to cerebrospinal fluid of a subject. Referring to **FIG. 11**, cerebrospinal fluid (CSF) **6** exits the foramen of Magendie and Luschka to flow around the brainstem and cerebellum. The arrows within the subarachnoid space **3** in **FIG. 11** indicate cerebrospinal fluid **6** flow. The subarachnoid space **3** is a compartment within the central nervous system that contains cerebrospinal fluid **6.** The cerebrospinal fluid **6** is produced in the ventricular system of the brain and communicates freely with the subarachnoid space **3** via the foramen of Magendie and Luschka. A composition containing an anti-Aβ antibody complex may be delivered to cerebrospinal fluid **6** of a subject anywhere that the cerebrospinal fluid **6** is accessible. For example, the composition may be administered intrathecally or intracerebroventricularly.

[150] **FIG. 12** illustrates a representative implantable system configured for intrathecal delivery of a composition containing an anti-Aβ antibody complex. As shown in **FIG. 12**, a system or device **30** may be implanted below the skin of a patient. Preferably the device **30** is implanted in a location where the implantation interferes as little as practicable with activity of the subject in which it is implanted. One suitable location for implanting the device **30** is subcutaneously in the lower abdomen. In various embodiments, catheter **38** is positioned so that the distal end **39** of catheter **38** is located in the subarachnoid space **3** of the spinal cord such that a delivery region (not shown) of catheter is also located within the subarachnoid space **3**. It will be understood that the delivery region can be placed in a multitude of locations to direct delivery of an agent to a multitude of locations within the cerebrospinal fluid **6** of the patient. The location of the distal end **39** and delivery region(s) of the catheter **38** may be adjusted to improve therapeutic efficacy.

[151] According to various embodiments, a composition containing an anti-Aβ antibody complex may be delivered intraparenchymally directly to brain tissue of a subject. An infusion device may be used to deliver the agent to the brain tissue. A catheter may be operably coupled to the infusion device and a delivery region of the catheter may be placed in or near a target region of the brain.

[152] One suitable system for administering a therapeutic agent to the brain is discussed in U.S. Pat. No. 5,711,316 (Elsberry). Referring to **FIG. 13**, a system or infusion device **10** may be implanted below the skin of a subject. The device **10** may have a port **14** into which a hypodermic needle can be inserted through the skin to inject a quantity of a composition comprising a therapeutic agent. The composition is delivered from device **10** through a catheter port **20** into a catheter **22**. Catheter **22** is positioned to deliver the agent to specific infusion sites in a brain (**B**). Device **10** may take the form of the like-numbered device shown in U.S. Pat. No. 4,692,147 (Duggan), assigned to Medtronic, Inc., Minneapolis, Minn, or take the form of a SYNCHROMED II® (Medtronic, Inc.) infusion device. The distal end of catheter **22** terminates in a cylindrical hollow tube **22A** having a distal end **115** implanted into a target portion of the brain by conventional stereotactic surgical techniques. Additional details about end **115**, according to various embodiments, may be obtained from U.S. application Ser. No. 08/430,960 entitled "Intraparenchymal Infusion Catheter System," filed Apr. 28, 1995 in the name of Dennis Elsberry et al. and assigned to the same assignee as the present application. Tube **22A** is surgically implanted through a hole in the skull **123** and catheter **22** is implanted between the skull and the scalp **125** as shown in **FIG. 13**. Catheter **22** may be coupled to implanted device **10** in the manner shown or in any other suitable manner.

[153] Referring to **FIG. 14**, a therapy delivery device **10** is implanted in a human body **120** in the location shown or may be implanted in any other suitable location. Body **120** includes arms **122** and **123**. In various embodiments and as depicted, catheter **22** is divided into twin or similar tubes **22A** and **22B** that are implanted into the brain bilaterally. In some embodiments, tube **22B** is supplied with a composition from a separate catheter and pump. Of course, unilateral delivery may be performed in accordance with the teachings presented herein.

[154] Referring to **FIG. 15**, an anti-Aβ antibody complex may be delivered to a subject's CNS via an injection port **10** implanted subcutaneously in the scalp of a patient **1**, e.g. as described in US Patent No. 5,954,687 or otherwise known in the art. A guide catheter **10** may be used to guide an infusion catheter through port **10** to a target location. Of course, an infusion catheter may be directly be inserted through port **10** to the target location.

[155] Any other known or developed implantable or external infusion device or port may be employed.

[156] Referring to **FIG. 16**, a representative system including an infusion device **30** and a sensor **500** is shown. The sensor **500** may detect an attribute of the nervous system, which attribute may reflect a pathology associated with a disease to be treated or studied or the amount of antibody already in the targeted region. A microprocessor **42** may analyze output from the sensor **50** and regulate the amount of antibody delivered to the brain. Sensor **500** may be operably coupled to processor **42** in any manner. For example, sensor **500** may be connected to processor via a direct electrical connection, such as through a wire or cable, or via wireless communication. Sensed information, whether processed or not, may be recoded by device **30** and stored in memory (not shown). The stored sensed memory may be relayed to an external programmer, where a physician may modify one or more parameter associated with the therapy based on the relayed information. Alternatively, based on the sensed information, processor **42** may adjust one or more parameters associated with therapy delivery. For example, processor **42** may adjust the amount or timing of the infusion of an anti-Aβ antibody. It will be understood that two or more sensors **500** may be employed.

[157] Sensor **500** may detect a polypeptide associated with a CNS disorder to be treated or investigated; a physiological effect, such as a change in membrane potential; a clinical response, such as blood pressure; or the like. In various embodiments, a component of an infused composition, such as the anti-Aβ antibody or other component, which may be added specifically for the purpose of detection by the sensor **500**, is detected. Any suitable sensor **500** may be used. A biosensor may be used to detect the presence of a polypeptide or other molecule in a patient. Any known or future developed biosensor may be used. The biosensor may have, e.g., an enzyme, an antibody, a receptor, or the like operably coupled to, e.g., a suitable physical transducer capable of converting the biological signal into an electrical signal. In some situations, receptors or enzymes that reversibly bind the molecule being detected may be preferred. In various embodiments, sensor **500** is a sensor as described in, e.g., U.S. Pat. No. 5,978,702, entitled TECHNIQUES OF TREATING EPILEPSY BY BRAIN STIMULATION AND DRUG INFUSION, or U.S. patent application Ser. No. 10/826,925, entitled COLLECTING SLEEP QUALITY

INFORMATION VIA A MEDICAL DEVICE, filed Apr. 15, 2004, or U.S. patent application Ser. No. 10/820,677, entitled DEVICE AND METHOD FOR ATTENUATING AN IMMUNE RESPONSE, filed Apr. 8, 2004.

[158] Examples of sensor technology that may be adapted for use in some embodiments include those disclosed in: (i) U.S. Patent No. 5,640,764 for "Method of forming a tubular feed-through hermetic seal for an implantable medical device;" (ii) U.S. Patent No. 5,660,163 for "Glucose sensor assembly;" (iii) U.S. Patent No. 5,750,926 for "Hermetically sealed electrical feedthrough for use with implantable electronic devices;" (iv) U.S. Patent No. 5,791,344 for "Patient monitoring system;" (v) U.S. Patent No. 5,917,346 for "Low power current to frequency converter circuit for use in implantable sensors;" (vi) U.S. Patent No. 5,957,958 for "Implantable electrode arrays;" (vii) U.S. Patent No. 5,999,848 for "Daisy chainable sensors and stimulators for implantation in living tissue;" (viii) U.S. Patent No. 6,043,437 for "Alumina insulation for coating implantable components and other microminiature devices;" (ix) U.S. Patent No. 6,088,608 for "Electrochemical sensor and integrity tests therefor;" or (x) U.S. Patent No. 6,259,937 for "Implantable substrate sensor."

[159] In the following, non-limiting examples are presented, which describe various embodiments of the antibodies, antibody complexes, and methods discussed above.

EXAMPLES

[160] In the Examples that follow, recombinant DNA techniques were performed using methods well known in the art and, as appropriate, supplier instructions for use of enzymes were used in these methods. Sources of general methods included Molecular Cloning, A Laboratory Manual, 3rd edition, vols 1-3, eds. Sambrook and Russel (2001) Cold Spring Harbor Laboratory Press, and Current Protocols in Molecular Biology, ed. Ausubel, John Wiley and Sons. Detailed laboratory methods are also described below. Analysis of T cell epitopes was performed according to methods published in PCT/GB2007/000736 (Antitope Ltd).

[161] EXAMPLE 1: Chimeric 6E10

[162] mRNA was extracted from the hybridoma 6E10 cells (Covance, Inc., Emeryville, CA) using a Poly A Tract System 1000 mRNA extraction kit (Promega Corp. Madison WI) according to manufacturer's instructions. mRNA was reverse transcribed as follows. For the kappa light chain, 5.0 microliter of mRNA was mixed with 1.0 microliter of 20 pmol/ microliter MuIgGκV_L-3' primer OL040 (Table 2) and 5.5 microliter nuclease free water (Promega Corp. Madison WI). For the lambda light chain, 5.0 microliter of mRNA was mixed with 1.0 microliter of 20 pmol/microliter MuIgGλV_L-3' primer OL042 (**Table 2**) and 5.5 microliter nuclease free water (Promega Corp. Madison WI). For the gamma heavy chain, 5 microliter of mRNA was mixed with 1.0 microliter of 20 pmol/ microliter MuIgGV_H-3' primer OL023 (Table 1) and 5.5μl nuclease free water (Promega Corp. Madison WI). All three reaction mixes were placed in the pre-heated block of the thermal cycler set at 70°C for 5 minutes. These were chilled on ice for 5 minutes before adding to each 4.0 microliter ImPromII 5x reaction buffer (Promega Corp. Madison WI), 0.5 microliter RNasin ribonuclease inhibitor (Promega Corp. Madison WI), 2.0 microliter 25mM $MgCl_2$ (Promega Corp. Madison WI), 1.0 microliter 10mM dNTP mix (Invitrogen, Paisley UK) and 1.0 microliter Improm II reverse transcriptase (Promega Corp. Madison WI). The reaction mixes were incubated at room temperature for 5 minutes before being transferred to a pre-heated PCR block set at 42°C for 1 hour. After this time the reverse transcriptase was heat inactivated by incubating at 70°C in a PCR block for fifteen minutes.

[163] Heavy and light chain sequences were amplified from cDNA as follows: A PCR master mix was prepared by adding 37.5 microliter 10x Hi-Fi Expand PCR buffer: (Roche, Mannheim Germany), 7.5 microliter 10mM dNTP mix (Invitrogen, Paisley UK) and 3.75 microliter Hi-Fi Expand DNA polymerase (Roche, Mannheim Germany) to 273.75 microliter nuclease free water. This master mix was dispensed in 21.5 microliter aliquots into 15 thin walled PCR reaction tubes on ice. Into six of these tubes was added 2.5 microliter of MuIgVH-3' reverse transcription reaction mix and 1.0 microliter of heavy chain 5' primer pools HA to HF (see **Table 1** for primer sequences and primer pool constituents). To another seven tubes was added 2.5 microliter of MuIgKVL-3' reverse transcripton reaction and 1.0 microliter of light chain 5' primer pools LA to LG (Table 2). Into the final tube was added 2.5 microliter of MuIgKVL-3' reverse transcripton reaction and 1.0 microliter of lambda light chain primer MuIgλVL5'-LI. Reactions were placed in

the block of the thermal cycler and heated to 95°C for 2 minutes. The PCR reaction was performed for 40 cycles of 94°C for 30 seconds, 55°C for 1 minute and 72°C for 30 seconds. Finally the PCR products were heated at 72°C for 5 minutes, and then held at 4°C.

[164] Amplification products were cloned into pGEM-T easy vector using the pGEM-T easy Vector System I (Promega Corp. Madison WI) kit and sequenced. The resultant mouse VH (SEQ. ID. NO. 36) and VL (SEQ. ID. NO. 37) sequences are shown in **FIG. 2** ("Mouse").

[165] For generation of a chimeric antibody, VH region genes were amplified by PCR using the primers OL330, GATCACGCGTGTCCACTCCGAAGTGCAGCTGGTGGAGTC (**SEQ ID NO. 63**), and OL331, GTACAAGCTTACCTGAGGAGACGGTGACTGAGG (**SEQ ID NO. 64**); these were designed to engineer in a 5' MluI and a 3' HindIII restriction enzyme site using plasmid DNA from one of the cDNA clones as template. Into a 0.5ml PCR tube was added 5 microliter 10x Hi-Fi Expand PCR buffer: (Roche, Mannheim Germany), 1.0 microliter 10mM dNTP mix (Invitrogen, Paisley UK), 0.5 microliter of Primer OL330, 0.5 microliter of primer OL331, 1.0 microliter template DNA and 0.5 microliter Hi-Fi Expand DNA polymerase (Roche, Mannheim Germany) to 41.5 microliter nuclease free water.

[166] VL regions were amplified in a similar method using the oligonucleotides OL332, CATGGCGCGCGATGTGACATCCAGATGACTCAGTC (**SEQ ID NO. 65**), and OL333, TGCGGGATCCAACTGAGGAAGCAAAGTTTAAATTCTACTCACGTCTCAGCTCCA GCTTGGTCC (**SEQ ID NO. 66**), to engineer in BssHII and BamHI restriction enzyme sites. Reactions were placed in the block of the thermal cycler and heated to 95°C for 2 minutes. The polymerase chain reaction (PCR) reaction was performed for 30 cycles of 94°C for 30 seconds, 55°C for 1 minute and 72°C for 30 seconds. Finally the PCR products were heated at 72°C for 5 minutes, and then held at 4°C. VH and VL region PCR products were then cloned into the vectors pANT15 and pANT13 respectively (**FIG. 1**) at the MluI/HinDIII and BssHII/BamHI sites respectively. Both pANT15 and pANT13 are pAT153-based plasmids containing a human Ig expression cassette. The heavy chain cassette in pANT15 consists of a human genomic IgG1 constant region gene driven by hCMVie promoter, with a downstream human IgG polyA region. pANT15 also contains a hamster *dhfr* gene driven by the SV40 promoter with a downstream SV40 polyA region.

The light chain cassette of pANT13 includes the genomic human kappa constant region driven by hCMVie promoter with downstream light chain polyA region. Cloning sites between a human Ig leader sequence and the constant regions allow the insertion of the variable region genes.

[167] NS0 cells (ECACC 85110503, Porton, UK) were co-transfected with these two plasmids via electroporation and selected in DMEM (Invitrogen, Paisley UK) + 5% FBS (Ultra low IgG Cat No. 16250-078 Invitrogen, Paisley UK) + Penicillin/Streptomycin (Invitrogen, Paisley UK) + 100nM Methotrexate (Sigma, Poole UK). Methotrexate resistant colonies were isolated and antibody was purified by Protein A affinity chromatography using a 1ml HiTrap MabSelect Sure column (GE Healthcare, Amersham UK) following the manufacturers recommended conditions.

[168] NS0 supernatants were quantified for antibody expression in IgG Fc/Kappa ELISA using purified human IgG1/Kappa (Sigma, Poole UK) as standards. Immunosorb 96 well plates (Nalge nunc Hereford, UK) were coated with mouse anti-human IgG Fc-specific antibody (I6260 Sigma, Poole UK) diluted at 1:1500 in 1xPBS (pH 7.4) at 37°C for 1 hour. Plates were washed three times in PBS+0.05% Tween 20 before adding samples and standards, diluted in 2% BSA/PBS. Plates were incubated at RT for 1 hour before washing three times in PBS/Tween and adding 100µl/well of detecting antibody goat anti-human kappa light chain peroxidase conjugate (A7164 Sigma, Poole UK) diluted 1:1000 in 2% BSA/PBS. Plates were incubated at RT for 1 hour before washing five times with PBS/tween and bound antibody detected using OPD substrate (Sigma, Poole UK). The assay was developed in the dark for 5 minutes before being stopped by the addition of 3M HCl. The assay plate was then read in a MRX TCII plate reader (Dynex Technologies, Worthing, UK) at 490nm.

[169] The chimeric antibody was tested in an ELISA-based competition assay using 6E10 mouse antibody, biotinylated using Biotintag micro biotinylation kit (Sigma, Poole UK).

[170] Biotinylated mouse 6E10 antibody was diluted to 0.25µg/ml and mixed with equal volumes of competing antibody at concentrations ranging from 3ng/ml-16µg/ml. 100µl of the antibody mixes were transferred into the wells of Immulon Maxisorb plates precoated with 0.06125µg/ml $Abeta_{42}$ beta amyloid peptide coated plates and incubated at room temperature for 1 hour. The plate was washed, and bound biotinylated mouse 6E10 was detected by adding a strepavidin-HRP conjugate (Sigma, Poole UK) (diluted at 1:500) and OPD substrate (Sigma, Poole UK). The assay was developed in the dark for 5 minutes before being stopped by the addition of 3M HCl. The assay plate was then read in a MRX TCII plate reader at absorbance 490nm.

Table 1: Primer sequences and primer pool constituents

Code	Sequence	Length	Name-Pool
OL007	ATGRASTTSKGGYTMARCTKGRTTT (**SEQ ID NO:1**)	25	MuIgV$_H$5'-HA
OL008	ATGRAATGSASCTGGGTYWTYCTCTT (**SEQ ID NO:2**)	26	MuIgV$_H$5'-HB
OL009	ATGGACTCCAGGCTCAATTTAGTTTTCCT (**SEQ ID NO:3**)	29	MuIgV$_H$5'-HC
OL010	ATGGCTGTCYTRGBGCTGYTCYTCTG (**SEQ ID NO:4**)	26	MuIgV$_H$5'-HC
OL011	ATGGVTTGGSTGTGGAMCTTGCYATTCCT (**SEQ ID NO:5**)	29	MuIgV$_H$5'-HC
OL012	ATGAAATGCAGCTGGRTYATSTTCTT (**SEQ ID NO:6**)	26	MuIgV$_H$5'-HD
OL013	ATGGRCAGRCTTACWTYYTCATTCCT (**SEQ ID NO: 7**)	26	MuIgV$_H$5'H-D
OL014	ATGATGGTGTTAAGTCTTCTGTACCT (**SEQ ID NO:8**)	26	MuIgV$_H$5'-HD
OL015	ATGGGATGGAGCTRTATCATSYTCTT (**SEQ ID NO:9**)	26	MuIgV$_H$5'-HE
OL016	ATGAAGWTGTGGBTRAACTGGRT (**SEQ ID NO:10**)	23	MuIgV$_H$5'-HE
OL017	ATGGRATGGASCKKIRTCTTTMTCT (**SEQ ID NO:11**)	25	MuIgV$_H$5'-HE
OL018	ATGAACTTYGGGYTSAGMTTGRTTT (**SEQ ID NO:12**)	25	MuIgV$_H$5'-HF
OL019	ATGTACTTGGGACTGAGCTGTGTAT (**SEQ ID NO:13**)	25	MuIgV$_H$5'-HF
OL020	ATGAGAGTGCTGATTCTTTTGTG (**SEQ ID NO:14**)	23	MuIgV$_H$5'-HF
OL021	ATGGATTTTGGGCTGATTTTTTTTATTG	28	MuIgV$_H$5'-HF

	(**SEQ ID NO:15**)		
OL023	CCAGGGRCCARKGGATARACIGRTGG (**SEQ ID NO:16**)	26	MuIgGV$_H$3'-2

Table 2: Primer sequences and primer pool constituents

Code	Sequence	Length	Name-Pool
OL024	ATGRAGWCACAKWCYCAGGTCTTT (**SEQ. ID. NO. 17**)	24	MuIgkV$_L$5'-LA
OL025	ATGGAGACAGACACACTCCTGCTAT (**SEQ. ID. NO. 18**)	25	MuIgkV$_L$5'-LB
OL026	ATGGAGWCAGACACACTSCTGYTATGGGT (**SEQ. ID. NO. 19**)	29	MuIgkV$_L$5'-LC
OL027	ATGAGGRCCCCTGCTCAGWTTYTTGGIWTCTT (**SEQ. ID. NO. 20**)	32	MuIgkV$_L$5'-LD
OL028	ATGGGCWTCAAGATGRAGTCACAKWYYCWGG (**SEQ. ID. NO. 21**)	31	MuIgkV$_L$5'-LD
OL029	ATGAGTGTGCYCACTCAGGTCCTGGSGTT (**SEQ. ID. NO. 22**)	29	MuIgkV$_L$5'-LE
OL030	ATGTGGGGAYCGKTTTYAMMCTTTTCAATTG (**SEQ. ID. NO. 23**)	31	MuIgkV$_L$5'-LE
OL031	ATGGAAGCCCCAGCTCAGCTTCTCTTCC (**SEQ. ID. NO. 24**)	28	MuIgkV$_L$5'-LE
OL032	ATGAGIMMKTCIMTTCAITTCYTGGG (**SEQ. ID. NO. 25**)	26	MuIgkV$_L$5'-LF
OL033	ATGAKGTHCYCIGCTCAGYTYCTIRG (**SEQ. ID. NO. 26**)	26	MuIgkV$_L$5'-LF
OL034	ATGGTRTCCWCASCTCAGTTCCTTG (**SEQ. ID. NO. 27**)	25	MuIgkV$_L$5'-LF
OL035	ATGTATATATGTTTGTTGTCTATTTCT (**SEQ. ID. NO. 28**)	27	MuIgkV$_L$5'-LF
OL036	ATGAAGTTGCCTGTTAGGCTGTTGGTGCT (**SEQ. ID. NO. 29**)	29	MuIgkV$_L$5'-LG
OL037	ATGGATTTWCARGTGCAGATTWTCAGCTT (**SEQ. ID. NO. 30**)	29	MuIgkV$_L$5'-LG

OL038	ATGGTYCTYATVTCCTTGCTGTTCTGG (**SEQ. ID. NO. 31**)	27	MuIgkV$_L$5'-LG
OL039	ATGGTYCTYATVTTRCTGCTGCTATGG (**SEQ. ID. NO. 32**)	27	MuIgkV$_L$5'-LG
OL040	ACTGGATGGTGGGAAGATGGA (**SEQ. ID. NO. 33**)	21	MuIgkV$_L$3'-1
OL041	ATGGCCTGGAYTYCWCTYWTMYTCT (**SEQ. ID. NO. 34**)	25	MuIgλV$_L$5'-LI
OL042	AGCTCYTCWGWGGAIGGYGGRAA (**SEQ. ID. NO. 35**)	23	MuIgλV$_L$3'-1

[171] EXAMPLE 2: Deimmunized 6E10

[172] Peptides of 15 amino acids length with overlaps of 12 amino acids were synthesised from the VH and VL sequences of mouse 6E10 (**FIG. 2**). For VH and VL, 36 and 34 peptides respectively were synthesised, in both cases starting from the N terminal amino acid in the sequence. These peptides were then analysed in human T cell assays using the method described in PCT/GB2007/000736 (Antitope Ltd). This revealed the presence of four T cell epitopes from the following peptides:

VH19-33 KLSCTASGFNIKDTY (amino acids 19-33 of **SEQ ID NO:36**);
VH79-93 TAYLHLNSLTSEDTA (amino acids 79-93 of **SEQ ID NO:36**);
VL10-24 SLTVTAGEKVALTCK (amino acids 10-24 of **SEQ ID NO:37**); and
VL79-93 LTISSVQAEDLAVYY (amino acids 79-93 of **SEQ ID NO:37**).

[173] The peptides are underline in the "mouse" sequence provided in **FIG. 2**.

[174] A range of variants of these peptides were retested in human T cell assays incorporating amino acid substitutions for amino acids present at the corresponding positions in other antibody V regions. From this analysis, the following variant peptides were negative in human T cell assays (with substitutions underlined):

VH19-33 KVSCTASGFNIKDTY (**SEQ ID NO:38**)
VH79-93 TAYMELSSLRSEDTA (**SEQ ID NO:39**)
VL10-24 SLTVTAGEDAALTCK (**SEQ ID NO:40**)

VL79-93 LTISSVTAEDLAVYY (**SEQ ID NO:41**)

[175] Deimmunized VH and VL sequences were designed to incorporate the variant peptide sequences as above. Sequences of the deimmunized variants (**SEQ ID NO:42** and **SEQ ID NO:43**) are given in **FIG. 2** ('DeI'). Deimmunized V region genes were constructed using the mouse 6E10 VH and VL templates for PCR using long overlapping oligonucleotides to introduce amino acids corresponding to the variant peptide sequences as above. Variant genes were cloned directly into the expression vectors pANT15 and pANT13 and transfected into NS0 as detailed in Example 1. Binding of deimmunized antibody was tested in the competition binding ELISA described in Example 1.

[176] EXAMPLE 3: Humanized 6E10

[177] Humanized VH and VL sequences were designed by comparison of mouse 6E10 sequences and homologous human VH and VL sequences. From this analysis, the human VH region VH1-46 was chosen to provide frameworks for grafting of 6E10 VH CDRs as shown in **FIG. 2** ('Graft1', **SEQ ID NO:44**). The human VL region B3 was chosen to provide frameworks for grafting of 6E10 VL CDRs as shown in **FIG. 2** ('Graft', **SEQ ID NO:45**). A variant of the humanized VH sequence was designed as shown in **FIG. 2** ('Graft2', **SEQ ID NO:46**) where six framework residues (amino acids 23, 48, 71, 73, 78 and 93 using Kabat numbering) were converted back to the corresponding mouse VH residues. The retention of these six amino acids was considered important due to internal folding or interactions with CDRs (for example, see US2006073137 (Celltech Limited)). Humanized V region genes were constructed using the mouse 6E10 VH and VL templates for PCR using long overlapping oligonucleotides to introduce amino acids from homologous human VH and VL sequences. Variant genes were cloned directly into the expression vectors pANT15 and pANT13 and transfected into NS0 as detailed in Example 1. Binding of humanized antibody variants were tested in the competition binding ELISA described in Example 1.

[178] EXAMPLE 4: Composite human antibody variants of 6E10

[179] Composite human VH and VL sequences were designed by comparison of mouse 6E10 sequences and fragments of different naturally occurring human VH and VL sequences and selection of such human fragments to build the composite human sequences. The choice of human VH and VL sequence fragments was constrained for the presence of certain amino acids at corresponding positions in 6E10 which were considered to be potentially important for antibody binding in conjunction with CDRs from 6E10. For VH, these amino acids were 1, 11, 23, 41, 48, 67, 71, 73, 76, 78 and 93 (Kabat numbering). For VL, these amino acids were 12, 63 and 70 (Kabat numbering). A bias was also used for the selection of human VH and VL sequence fragments where fragments were chosen for homology to certain human germline framework regions of closest homology to the 6E10 VH and VL. For VH, these were VH1-46 for framework 1 (VHFR1), VH1-58 for VHFR2, VH1-69 for VHFR3 and J4 for the J region. For VL, these were A14 for VLFR1, B3 for VLFR2, B3 for VHFR3 and J4 for the J region. From this analysis, a series of composite human VH and VL sequences were designed as shown in **FIG. 2** ('CHAB', **SEQ ID NOs: 47-54**, corresponding nucleotide sequences are shown in **FIGs. 3-5**, **SEQ ID NOs: 55-62**). Composite human V region genes were constructed using the mouse 6E10 VH and VL templates for PCR using long overlapping oligonucleotides to introduce amino acids from human VH and VL sequence fragments.

[180] Variant genes were cloned directly into the expression vectors pANT15 and pANT13 and transfected into NS0 as detailed in Example 1. All combinations of composite heavy and light chains (i.e. a total of 15 pairings) were stably transfected into NS0 cells by electroporation and selected in media (high glucose DMEM with L-glutamine and Na pyruvate, 5% ultra-low IgG FCS, pen/strep – all from Invitrogen, Paisley, UK) containing 200nM methotrexate. Several drug resistant colonies for each construct were tested for expression levels and the best expressing lines were selected and frozen under liquid nitrogen.

[181] Binding of humanized variants were tested in the competition binding ELISA described in Example 1. Briefly, supernatants from the best expressing lines for each combination were quantified using an Fc capture, Kappa light chain detection ELISA in comparison to a IgG1/kappa standard. The quantified supernatants were then tested in a competition ELISA for binding to their target antigen, beta amyloid. 96 well maxisorb plates (Nunc - Fisher Scientific, Loughborough, UK) were coated overnight at 4°C with 50 μl/well of 0.06125 μg/ml beta amyloid (Covance, UK) in carbonate buffer pH 9.6. Duplicate titrations of mouse MDT-2007 antibody and COMPOSITE HUMAN ANTIBODY™ (Antitope Ltd.) samples were generated (in the range 0.003 µg/ml to16 µg/ml) and mixed with a constant concentration (0.25 ug/ml) of biotinylated mouse MDT-2007 antibody in PBS pH 7.4/0.5% BSA/ 0.05%Tween. The titrations, 50 µl/well, were added to washed (3x with PBS pH 7.4/0.5%BSA/0.05% Tween 20) assay plates and incubated at room temperature for 1 hour. Plates were washed as above and 100 µl/well of a 1/500 dilution of streptavidin HRP (Sigma, Poole, UK) in PBS pH 7.4/0.5% BSA/ 0.05%Tween was added and incubated for a further 1 hour at room temperature. After a further wash, bound biotinylated mouse MDT-2007 antibody was detected with 100 µl/well TMB substrate. After stopping the reaction with 50 µl/well 3M HCl, absorbance was measured at 450 nm and the binding curves of the test antibodies were compared to the mouse reference standard. Absorbance was plotted against sample concentration and straight lines were fitted through each of the data sets. The equations of the lines were used to calculate the concentration required to inhibit Biotin-MDT-2007 binding to beta amyloid by 50% (IC_{50}). The IC_{50} values were used to calculate the fold difference in binding efficiencies and these values are reported in **Table 3**.

Table 3: Anti-Beta Amyloid COMPOSITE HUMAN ANTIBODY™ (Antitope Ltd.) Sequence Variants Matrix of Binding Efficiencies Relative to Mouse MDT-2007

	VK1	VK2	VK3
VH1	0.78	-	1.93
VH2	-	1.10	0.96
VH3	-	-	1.57
VH4	**0.94**	**0.67**	1.36
VH5	**0.80**	**0.72**	1.02

[182] The data presented in **Table 3** is from a competition assay. Anti-beta amyloid humanized antibodies were used in a competition assay with biotinylated mouse (6E10). IC_{50} values were normalized against the binding of the mouse 6E10 anti-Aβ antibody so that 1 is equal to the mouse antibody binding and a value <1 is improved binding relative to mouse 6E10.

[183] Based on these data and the sequences of the humanized antibodies, four antibodies were selected as lead candidates (highlighted in bold in **Table 3**). Cell lines for these variants were expanded to 100 ml and grown to saturation. Antibodies were purified from each culture via protein A affinity chromatography. Briefly, supernatants were pH adjusted with 0.1 volume of 10x PBS pH 7.4 and passed over 1ml Mab Select Sure protein A columns (GE Healthcare, Amersham, UK). The columns were washed with 10 volumes of PBS pH 7.4 before elution with 50mM citrate buffer pH 3.0. 1 ml fractions were collected and immediately neutralized with 0.1 ml of 1m Tris-HCl pH 9.0. Protein containing fractions (as judged by absorbance at 280nm) were pooled, buffer exchanged into PBS pH 7.4 and the purified antibodies stored at +4°C. An SDS-PAGE gel of 1μg of each antibody was run and stained with coomassie blue. The concentrations of the antibodies were calculated by UV absorption based upon a calculated molar extinction coefficient such that $E_{0.1\%}$ at 280nm = 1.45.

[184] The purified antibodies were tested for binding to beta amyloid via competition ELISA as described above (n=2). Titrations of the test antibodies were done from 0.003 μg/ml to 16 μg/ml in duplicate. Absorbance at 450 nm was measured and this was plotted against test antibody concentration.

[185] **Table 4** summarizes the results for the combinations of the composite VH and VK variant sequences obtained from a competition assay performed over a wide range of concentrations (0.003 μg/ml to 16 μg/ml) for the anti-beta amyloid antibodies. Three of the humanized antibodies have an IC_{50} that is improved compared to the mouse reference, particularly VH4/VK2 that has a measured 1.72 fold increase in binding in this assay.

Table 4: IC_{50} Values for Anti-Beta Amyloid COMPOSITE HUMAN ANTIBODY™ (Antitope Ltd.) Sequence Variants

Antibody	IC50 μg/ml	Fold Difference
Mouse	3.6	1
VH4/VK1	4.1	1.14
VH4/VK2	**2.1**	**0.57**
VH5/VK1	3.3	0.91
VH5/VK2	2.6	0.72

[186] The data provided in **Table 4** were obtained from a competition assay with biotinylated chimeric mouse 6E10 antibody. IC_{50} values are displayed and are also normalized against the binding of chimeric mouse 6E10 so that 1 is equal to chimeric mouse 6E10 antibody binding and a value <1 is improved binding relative to chimeric mouse 6E10 antibody.

[187] **Tables 5-8** show the human sequences from which the humanized antibodies were derived.

Table 5: VH4 sequences from which humanized antibodies were derived

Genbank Accession No.	VH4 Sequence
AAC18394	QVQLVQSGAEVKKPGASVKVSC (**SEQ ID NO:67**)
ABF83341	SVKVSCTAS (**SEQ ID NO:68**)
CAM57950	ASGFNIKDTYIHWVRQA (**SEQ ID NO:69**)
BAC02116	ARGQRLEWIGR (**SEQ ID NO:70**)
CAK50661	GRFDP (**SEQ ID NO:71**)
1313976D	VNVN (**SEQ ID NO:72**)
AAK68005	NTRY (**SEQ ID NO:73**)
AAK14005	DS (**SEQ ID NO:74**)
AAR32283	RFRGRV (**SEQ ID NO:75**)
AAR02486	FRGRVTIT (**SEQ ID NO:76**)
CAA85547	RVTITSDASTNTAY (**SEQ ID NO:77**)
BAC01408	TAYMELSSLRSEDTAVYYC (**SEQ ID NO:78**)
BAC02402	EDTAVYYCSR (**SEQ ID NO:79**)
ABK81616	RSYY (**SEQ ID NO:80**)
CAB56165	YNG (**SEQ ID NO:81**)
AAL59364	GRR (**SEQ ID NO:82**)
AAV40543	RR (**SEQ ID NO:83**)
AAA17922	FTY (**SEQ ID NO:84**)
IGHJ4*01	YWGQGTLVTVSS (**SEQ ID NO:85**)

Table 6: VH5 sequences from which humanized antibodies were derived

Genbank Accession No.	VH4 Sequence
AAC18394	QVQLVQSGAEVKKPGASVKVSC (**SEQ ID NO: 115**)
ABF83341	SVKVSCTAS (**SEQ ID NO: 116**)
CAM57950	ASGFNIKDTYIHWVRQA (**SEQ ID NO: 117**)
BAC02116	ARGQRLEWIGR (**SEQ ID NO:118**)
CAK50661	GRFDP (**SEQ ID NO:119**)
1313976D	VNVN (**SEQ ID NO:120**)
AAK68005	NTRY (**SEQ ID NO:121**)
AAK14005	DS (**SEQ ID NO:122**)
AAR32283	RFRGRV (**SEQ ID NO:123**)
AAR02486	FRGRVTIT (**SEQ ID NO:124**)
CAA85547	RVTITSDASTNTAY (**SEQ ID NO:125**)
BAC01408	TAYMELSSLRSEDTAVYYC (**SEQ ID NO:126**)
BAC02402	EDTAVYYCSR (**SEQ ID NO:127**)
ABK81616	RSYY (**SEQ ID NO:128**)
CAB56165	YNG (**SEQ ID NO:129**)
AAL59364	GRR (**SEQ ID NO:130**)
AAV40543	RR (**SEQ ID NO:131**)
AAA17922	FTY (**SEQ ID NO:132**)
IGHJ4*01	YWGQGTLVTVSS (**SEQ ID NO:133**)

Table 7: VK1 sequences from which humanized antibodies were derived

Genbank Accession No.	Vκ1 Sequence
CAA51125	DIVMTQSPDSLTVSLGERATINCK (**SEQ ID NO:86**)
AAQ21856	CKASQS (**SEQ ID NO:87**)
AAZ09112	SQSLL (**SEQ ID NO:88**)
CAA81698	LSS (**SEQ ID NO:89**)
CAE18257	GNQ (**SEQ ID NO:90**)
AAR89578	KNYLTWYQQKPGQPPKLLIYWAS (**SEQ ID NO:91**)
AAW67408	WYQQKPGQPPKLLIYWASIRESGVPDRF (**SEQ ID NO:92**)
BAC03964	SGVPDRFTGSGSGT (**SEQ ID NO:93**)
CAJ57189	GSGSGTFFTLTIS (**SEQ ID NO:94**)
BAC03964	FTLTISSLQAEDVAVYYCQ (**SEQ ID NO:95**)
AAQ21931	YYCQN (**SEQ ID NO:96**)
CAC94614	DYNYP (**SEQ ID NO:97**)
ABA26134	PFTFG (**SEQ ID NO:98**)
Human J2	TFGQGTKLEIK (**SEQ ID NO:99**)

Table 8: VK2 sequences from which humanized antibodies were derived

Genbank Accession No.	Vκ2 Sequence
AAD16249	DIVMTQSPSSL (**SEQ ID NO:100**)
AAO91645	MTQSPSSLTASVGDRVTITC (**SEQ ID NO:101**)
AAQ21856	CKASQS (**SEQ ID NO:102**)
AAZ09112	SQSLL (**SEQ ID NO:103**)
CAA81698	LSS (**SEQ ID NO:104**)
CAE18257	GNQ (**SEQ ID NO:105**)
AAR89578	KNYLTWYQQKPGQPPKLLIYWAS (**SEQ ID NO:106**)
AAW67408	WYQQKPGQPPKLLIYWASIRESGVPDRF (**SEQ ID NO:107**)
BAC03964	SGVPDRFTGSGSGT (**SEQ ID NO:108**)
CAJ57189	GSGSGTFFTLTIS (**SEQ ID NO:109**)
BAC03964	FTLTISSLQAEDVAVYYCQ (**SEQ ID NO:110**)
AAQ21931	YYCQN (**SEQ ID NO:111**)
CAC94614	DYNYP (**SEQ ID NO:112**)
ABA26134	PFTFG (**SEQ ID NO:113**)
Human J2	TFGQGTKLEIK (**SEQ ID NO:114**)

[188] EXAMPLE 5: Immunogenicity study of humanized anti-Aβ antibody, MDT-2007

[189] Sequence variant VH4/VK2 (see **Table 4**) has been designated MDT-2007 and will be referred to hereinafter as MDT-2007. MDT-2007 was subjected to a pre-clinical *ex vivo* T cell assay (EPISCREEN™, Antitope Ltd.). The EPISCREEN™ (Antitope Ltd.) assay provides an effective technology for predicting T cell immunogenicity by quantifying T cell responses to protein therapeutics. Using a cohort of community blood donors carefully selected based on MHC class II haplotypes, purified antibodies are tested for T cell immunogenicity in vitro using the EPISCREEN™ (Antitope Ltd.) time course T cell assay format. This assay provides a method by which the immunogenicity of whole proteins can be assessed both in terms of magnitude and frequency of T cell responses (Jones et al., J Interferon Cytokine Res. 2004 24(9):560-72; Jones et al., J Thromb Haemost. 2005 3(5):991-1000). Standard T cell assays provide a single time point 'snapshot' of the immune response and do not allow for natural variation in individual donors' response to antigens. The EpiScreen™ time course T cell assay samples donors' T cell responses over a four day period and the high degree of sensitivity along with the robust nature of the assay allows an accurate pre-clinical assessment of the potential for immunogenicity of the biologic being studied.

[190] 5.1. Methods

[191] 5.1.1 Purification of Antibodies

[192] MDT-2007 (Lot No. MED01) was used as test antibody in the EPISCREEN™ (Antitope Ltd.) assay. Control chimeric antibody was prepared fresh as follows: a 1L culture of chimeric antibody expressing cell-line was grown to saturation. Supernatant was separated from cells and debris, adjusted to pH 7.4, filter sterilized and run through 2x 1ml Hi-Trap Mab Select Pure affinity columns (GE Healthcare, Amersham, UK) at a flow rate of 1 ml/min. The columns were washed with 20 ml PBS pH 7.4 and eluted with sodium citrate buffer pH 3.0. Fractions were immediately neutralized with 0.1 volumes 1M Tris buffer pH 9.0. The protein content of each fraction was measured by UV absorption at 280 nm and protein containing fractions were pooled, buffer exchanged into PBS pH 7.4 and concentrated. The antibody was further purified by size exclusion chromatography using a 16/60 Sephacryl S200 column (GE Healthcare, Amersham, UK). The major peak fractions were collected, pooled, filter sterilized and stored at +4°C.

[193] Final concentrations were determined by UV absorption using calculated molar extinction coefficients, where A280 1.0 = 1.42 mg/ml. Each antibody was then diluted to100 μg/ml in AIMV culture medium (Invitrogen, Paisley, UK).

[194] 5.1.2 Preparation and Selection of Donor PBMC

[195] Peripheral blood mononuclear cells (PBMC) were isolated from healthy community donor buffy coats (from blood drawn within 24 hours) obtained from the National Blood Transfusion Service (Addenbrooke's Hospital, Cambridge, UK). PBMC were isolated from buffy coats by Lymphoprep (Axis-Shield, Dundee, UK) density centrifugation and CD8+ T cells were depleted using CD8+ ROSETTESEP™ (StemCell Technologies Inc., London, UK). Donors were characterized by identifying HLA-DR haplotypes using a Biotest SSP-

PCR based tissue-typing kit (Biotest, Landsteinerstraße, Denmark) as well as determining T cell responses to a control antigen keyhole limpet haemocyanin (KLH) (Pierce, Rockford, USA). PBMC were then frozen and stored in liquid nitrogen until required.

[196] A cohort of 20 donors was selected to best represent the number and frequency of HLADR allotypes expressed in the world population. Analysis of the allotypes expressed in the cohort against those expressed in the world population revealed that coverage of >80% was achieved and that all major HLA-DR alleles (individual allotypes with a frequency >5% expressed in the world population) were well represented. Details of individual donor haplotypes and a comparison of the frequency of MHC class II allotypes expressed in the world population and the sample population can be found in **Table 9** and **FIG. 6**, respectively.

[197] 5.1. Time Course T Cell Proliferation Assays

[198] PBMCs from each donor were thawed, counted and viability assessed. Cells were revived in room temperature AIMV culture medium (Invitrogen, Paisley, UK) and resuspended in AIMV to 4-6x106 PBMC/ml. For each donor, bulk cultures were established in which a total of 1ml proliferation cell stock was added a 24 well plate. A total of 1ml of each diluted test sample was added to the PBMC to give a final concentration of 50µg/ml per sample. For each donor, a positive control (cells incubated with 100µg/ml KLH) and a negative control (cells incubated with culture media only) were also included. Cultures were incubated for a total of 8 days at 37°C with 5% CO_2. On days 5, 6, 7 and 8, the cells in each well were gently resuspended and 3 x 100µl aliquots transferred to individual wells of a round bottomed 96 well plate. The cultures were pulsed with 1µCi [3H]-Thymidine (Perkin Elmer, Waltham, Massachusetts, USA) in 100µl AIMV culture medium and incubated for a further 18 hours before harvesting onto filter mats (Perkin Elmer, Waltham, Massachusetts, USA) using a TomTec Mach III cell harvester. Counts per minute (cpm) for each well were determined by MELTILEX™ (Perkin Elmer, Waltham, Massachusetts, USA) scintillation counting on a Microplate Beta Counter in paralux, low background counting.

[199] 5.1.4 Data Analysis

[200] For proliferation assays, an empirical threshold of a stimulation index (SI) equal to or greater than 2 (SI≥2) has been previously established whereby samples inducing proliferative responses above this threshold are deemed positive (where included, borderline SIs ≥1.95 are highlighted). Extensive assay development and previous studies have shown that this is the minimum signal to noise threshold allowing maximum sensitivity without detecting large numbers of false positive responses. For proliferation data sets (n=3), positive responses were defined by statistical and empirical thresholds:

1. Significance (p<0.05) of the response by comparing cpm of test wells against medium control wells using unpaired two sample student's t-test.

2. Stimulation index greater than 2 (SI≥2), where SI = mean of test wells (cpm)/mean medium control wells (cpm).

[201] In addition, intra-assay variation was assessed by calculating the coefficient of variance and standard deviation (SD) of the raw data from replicate cultures.

[202] 5.2 Results

[203] Both MDT-2007 and chimeric anti-Aβ42 were purified to homogeneity by Protein A affinity chromatography followed by size exclusion chromatography. Both preparations were derived from single peaks representing monomeric, non-aggregated antibody.

[204] The two test samples were tested against a cohort of 20 healthy donors using EPISCREEN™ (Antitope Ltd.) time course T cell assays in order to determine the relative risk of immunogenicity. The cohort was selected to best represent the number and frequency of HLA-DR allotypes expressed in the world population (**FIG. 6**). Donor haplotypes and the results of the control antigen tests are shown in Table 1. The samples were tested at a final concentration of 50μg/ml based on Antitope's previous experience showing that this saturating concentration is sufficient to stimulate detectable protein-specific T cell responses. The results from the current EPISCREEN™ (Antitope Ltd.) time course proliferation assay with MDT-2007 and chimeric antibody are shown in **FIG. 7** and summarised in **Table 10**.

[205] The chimeric antibody stimulated responses in 4 of the 20 donors where the SI ≥ 2, and significance was achieved in the Student's t-test with 5 donors (donor 1 gave a borderline SI of 1.96 that was significantly different from control), a rate of 25% (**FIG. 7(a)**). In contrast none of the donors responded to MDT2007. Results with the control antigen KLH show that the correlation between positive and negative results in Test 1 and Test 2 is good (**Table 9**), thus validating the assay. In addition all the basal cpm for the control wells are above the minimum specification for the assay of 150 cpm (Table 2).

[206] 5.3 Conclusions

[207] In general, the positive proliferation responses observed in the EPISCREEN™ (Antitope Ltd.) time course T cell assay against the chimeric antibody was in the expected range of 20-40%. Based on previous experience with other therapeutic antibodies if the frequency of responses >10% there is an association with an increased risk of immunogenicity in the clinic (**FIG. 8**). Importantly, frequent and potent T cell responses were observed against the control antigen, KLH, that indicate that the assay functioned as expected. The results also show that MDT-2007 failed to induce any positive responses in any donors which indicates that the frequency of positive responses is <5%, and therefore falls below the 10% threshold.

[208] **FIG. 8** shows a clear correlation between the level of immunogenicity observed using the EPISCREEN™ (Antitope Ltd.) assay and the level of immunogenicity (anti-protein therapeutic antibody responses) that has been actually observed in the clinic against a large panel of therapeutic proteins (Baker and Jones, Curr. Opin. Drug. Disc. Dev. 2007. **10**:219-217). High levels of immunogenicity were observed in both the clinical data and EPISCREEN™ (Antitope Ltd.) assays for proteins such as Infliximab and Campath, whereas relatively low levels of immunogenicity were observed for proteins such as Xolair, Herceptin, and Avastin. It is clear that MDT-2007 would therefore be considered as having a low potential risk of immunogenicity.

Table 9. HLA class II haplotypes and details of the study population.

Donor No.	Haplotpe	Test 1	MED01

1	DRB1*01, DRB1*11, DRB3	**3.31**	**4.15**
2	DRB1*09,DRB1*15,DRB4,DRB5	1.79	**2.59**
3	DRB1*15,DRB1*10,DRB5	1.17	0.89
4	DRB1*07,DRB1*08,DRB4	1.8	0.51
5	DRB1*14,DRB1*15,DRB3,DRB5	**2.98**	**2.06**
6	DRB1*04,DRB1*16,DRB4,DRB5	1.86	1.70
7	DRB1*03,DRB1*13,DRB3	**4.91**	0.97
8	DRB1*07,DRB1*15,DRB4,DRB5	1.15	1.96
9	DRB1*04,DRB1*07,DRB4	**10.31**	**4.08**
10	DRB1*03, DRB1*04, DRB3, DRB4	**2.91**	**3.82**
11	DRB1*03, DRB1*13, DRB3	n/d	**2.16**
12	DRB1*07, DRB1*13, DRB3,DRB4	1.81	**2.46**
13	DRB1*03,DRB1*11,DRB3	1.08	1.79
14	DRB1*04,DRB1*07,DRB4	**5.98**	**2.78**
15	DRB1*13,DRB3	**8.16**	**2.76**
16	DRB1*11,DRB1*13,DRB3	**3.39**	**3.06**
17	DRB1*03,DRB3	**4.42**	**2.03**
18	DRB1*07, DRB1*11, DRB3, DRB4	**3.41**	**3.96**
19	DRB1*03,DRB1*11,DRB3,DRB4	n/d	**5.17**
20	DRB1*01,DRB1*04,DRB4	**2.54**	**3.03**

[209] In **Table 9**, donor responses (SI) to KLH are shown for two independent tests. Test 1 was performed on freshly isolated PBMC and MED01 is from the current study. KLH-specific responses were measured on day 8 post stimulation for both tests values in bold text are considered as positive proliferation responses. Underlined values indicate differences in the test result (i.e. positive or negative).

Table 10. Summary of positive donor proliferation responses to chimeric anti-Aβ42 and MDT-2007.

Donor No.	Chimeric	MDT-2007	Basal CPM
1	+*	-	1089
2	-	-	980
3	-	-	1183
4	-	-	2903
5	-	-	1115
6	-	-	1266
7	-	-	682
8	-	-	492

9	-	-	546
10	+	-	1442
11	-	-	2162
12	-	-	1968
13	-	-	909
14	+	-	454
15	-	-	719
16	-	-	1451
17	-	-	2880
18	-	-	5209
19	+	-	1883
20	+	-	404
Positive Responses	**5 (25%)**	**0 (0%)**	

[210] In **Table 10,** positive proliferation (+) responses are indicated along with borderline proliferation (*) positive responses (SI range 1.95-1.99). All responses shown were significantly (p<0.05) different from untreated control wells. The mean counts per minute (cpm) are shown for untreated control wells (basal rate).

[211] EXAMPLE 6: Binding of MDT-2007 to brains of AD human and aged non-human primate

[212] Brain sections were washed 3 times with TBS (TBS = 12.1g Tris, 9.0g NaCl in one Lit dH2O) PH 7.4 with HCl then incubated with Sodium meta per lodate for 20 min ((2.139 Na meta Per Iodate/100 mL TBS). Sections were then washed with Wash with TBS/0.25%Triton 3 times and blocked with TBS/Triton/Goat Serum (3%) for 30 min, followed by a blocking wash consisting of TBS/Triton/Blocking Serum (1%). After blocking, the sections were incubated with Fab fragment Goat anti-Human IgG 1:200/TBS (Jackson Immuno Research Laboratory. Cat #109-007-003) /Triton 0.1%/ and G.S 1% for 1Hour followed by wash step with TBS. The primary antibody of interest (MDT-2007) was then added to the sections 1:10K in TBS/Triton/Goat Serum (1%)/1° Ab and kept overnight on shaker table at room temp. The second day, sections were washed with TBS/1% Blocking Serum three times and then incubated with 2Ab Biotin SP Conjugated AffiniPur Goat anti-Human IgG (Jackson Immuno Research Laboratory. Cat #109-065-003) 1:200/ TBS/1% Blocking serum for 1Hr. Sections were washed with TBS and then incubated again with ABC 135ul of A+ 135ul of B /50mL TBS (1:500) for 1 hr. Sections were then rinsed

with Imidizole Acetate Buffer 3 times(0.68g Imidizole, 6.8g. NaAc Trihydrate/1L dH_2O, pH w/glacial Acetic Acid to 7.4)

[213] As shown in **FIG. 9**, MDT-2007 bound to amyloid plaques in brains of both the aged rhesus monkey (**A**) and the 84 year-old female human diagnosed end stage Alzheimer's disease (eight year disease course) (**B**). The staining was more intense in the rhesus monkey than the human, with the human having a higher background and less intense plaque staining. Brains sections of a 26 yr old stump tail monkey were also stained (not shown) and resulted less staining compared to the rhesus monkey shown in **FIG. 9A**.

[214] EXAMPLE 7: Stability of MDT-2007 in infusion system under implant conditions

[215] Stability of MDT-2007 in a delivery system (SYNCHROMED II® (Medtronic, Inc.) implantable infusion device and Model 8910 polyurethane catheter, Medtronic, Inc.) was tested at two different concentrations and under two different flow parameters. MDT-2007 was diluted in Dulbecco's 1X PBS (without calcium and magnesium) to achieve 0.1 mg/ml and 1 mg/ml injectable compositions of MDT-2007. In the first cycle (4 wk duration) pumps were run at 600ul/day flow rate. In the second cycle (8 wk duration), upon refill of the pumps, the pumps were run at 300ul/day flow rate. All test conditions simulate potential clinical use (37°C set up, flow rates, concentrations, refill interval).

[216] The flow rate (i.e., the function of the pump) was not affected by the MDT-2007 formulations, possibly indicating that the MDT-2007 did not aggregate or precipitate and cause pump malfunction. MDT-2007 was found to be stable with 80% or greater recovery of active MDT-2007 (based on ELISA) infused from the infusion system. The 20% loss is believed to be due to adsorption of the antibody to components of the system, as steady state delivery was reached quickly.

[217] EXAMPLE 8: Conjugation of polysialic acid to anti-Aβ antibody increases bioavailability of the antibody

[218] Anti-Aβ antibodies obtained from hybridoma 6E10 cells (Covance, Inc., Emeryville, CA) or its $F(ab)_2$ fragments were conjugated to sialic acid-containing polymers (PSA) having 30 to 90 sialic acid units using a procedure employing periodate oxidation adapted from Liposomes: A Practical Approach (2^{nd} edition, 2003), edited by Vladimir Torchilin and

Volkmar Weissig, Oxford University Press, Oxford, UK, Protocol 7, pages 202-203, and Heath et al., *Biochem. Biophys. Acta*, 640, 66 (1981). The conjugation reaction employed sodium periodate activation of the PSA, contacting of the antibody or fragment with the activated PSA and adding sodium cyanoborohydride into the mixture. In brief, PSA (Sigma Aldrich, #C5762; 15.8mg for conjugation with 6E10 IgG and 10.5mg for conjugation with 6E10 F(ab`)$_2$) dissolved in borate buffer (0.4mL; 20mM sodium borate $Na_2B_4O_7{*}10H_20$, 120mM NaCl, pH 8.4) was incubated with sodium periodate solution (0.1 mL, 0.3 M in water) in a brown vial at ambient temperature for 30 min. The material was then transferred to a 10,000 molecular weight cut off (MWCO) Slide-A-Lyzer (purchased from Pierce, Rockford, IL) and dialyzed for approximately 4 hours against borate buffer (1 L). After dialysis, the material was transferred to a vial and mixed with 0.5 mg 6E10 IgG antibody or 6E10 F(ab`)$_2$. Into this mixture, sodium cyanoborohydride solution (15 µL, 2 M in 1M NaOH solution) was added. The materials were vortexed and incubated at 4°C or 37°C for 48 hours. Purification of the PSA conjugated to the antibody or antibody fragments was performed by dialyzing out the unconjugated antibody or antibody fragment against borate buffer overnight using the 50,000 MWCO Float-a-Lyzer (Spectra/Por #235046).

[219] Conjugated and unconjugated 6E10 IgG antibodies and its F(ab)$_2$ fragments were prepared for SDS-PAGE using the 2X sample buffer (BioRad, #161-0737) and run in an acrylamide gel (8%) at 65V for 15 min and 120V for 80min. The resulting gel was stained with Coomassie blue dye (SimplyBlue SafeStain, Invitrogen, #LC6060). In brief, the gel was microwaved in 100mL nanopure water in a loosely covered container for 1 min and washed with nanopure water thrice for 1 min each. After the last wash, 20 mL of SimplyBlue SafeStain was added and the gel microwaved for 1min. The gel was washed twice in 100mL of nanopure water for 10min each, and then incubated with 20 mL NaCl solution (20% in water) for 15 min before scanning it for results. As shown in **FIG. 17**, the protein band for conjugated IgG antibodies had a molecular weight of about 20 kDa greater than the unconjugated IgG antibodies, suggesting that the PSA was successfully conjugated to the antibody.

[220] The resulting conjugated antibodies (IgG and F(ab)$_2$ fragments) were subjected to dialysis to separate conjugated from unconjugated antibodies. The conjugated IgG antibodies were tested for their ability to bind amyloid beta (Aβ40 and Aβ42), using a western immunoblotting assay. In brief, Aβ40 or Aβ42 peptides (0.5µg in diluent; Covance) were diluted in 4 μl nanopure water and prepared with 2X sample buffer to run through 4-20% Pierce Precise Protein Gel at 55V for 15 min, and then at 100V for 55 min. The proteins were then transferred onto 0.2 μm nitrocellulose membrane at 6V for 30 min. The membrane was blocked with a solution of dried milk powder (5% in Tris-buffered saline with Tween20; TBST, 1L distilled water, 8 g NaCl, 2.4g Tris, pH 7.5 with HCl, 1 mL Tween20). Membranes were then incubated overnight with a 1000-fold dilution of unconjugated or PSA-conjugated 6E10 IgG or $F(ab`)_2$ preparations, washed thrice with TBST for 5 min each, incubated with 1:2000 dilution of HRP-conjugated goat anti-mouse secondary antibody, and washed twice again with TBST for 10 min each. The chemiluminscent signal was developed with ECL-Plus reagent and the membranes were exposed to Kodak films to illustrate the bands. The results presented in **FIG. 18** reveal that conjugating the antibody with PSA does not interfere with the ability of the antibody to bind amyloid beta.

[221] Dialyzed PSA-conjugated antibodies (IgG and $F(ab)_2$ fragments) were injected into mice (i.p.). Plasma samples were collected and analyzed for the injected antibody or antibody fragments as described in Thakker et al. 2009 PNAS 106, 4501-4506, except that the detection antibody was Fc non-specific. **FIG. 19** is a graph of the percentage of injected IgG or $F(ab)_2$ antibody (PSA-conjugated and unconjugated) detected in plasma of the mice 24 hours after i.p. injection. A three-fold increased was detected in 6E10 IgG conjugated with PSA relative to unconjugated 6E10 IgG. A 40-fold increase detected in 6E10 $F(ab)_2$ conjugated with PSA relative to unconjugated 6E10 $F(ab)_2$. This was surprising, as it appeared that little to no conjugation has occurred with the $F(ab)_2$ fragment (see, **FIG. 17**).

[222] In sum, these results support the proposition that conjugation of a sialic acid-containing molecule to an anti-amyloid beta antibody can improve bioavailability without significantly adversely affecting binding.

[223] Thus, embodiments of ANTI-AMYLOID BETA ANTIBODIES CONJUGATED TO SIALIC ACID-CONTAINING MOLECULES are disclosed. One skilled in the art will appreciate that the cell culture apparatuses and methods described herein can be practiced with embodiments other than those disclosed. The disclosed embodiments are presented for purposes of illustration and not limitation.

WHAT IS CLAIMED IS:

1. An antibody complex comprising:

an isolated anti-amyloid beta antibody; and

sialiac acid-containing molecule conjugated to the antibody.

2. An antibody complex according to claim 1, wherein the isolated antibody is a humanized antibody.

3. An antibody complex according to claim 1 or claim 2, wherein the isolated antibody comprises:

a variable heavy chain region including an amino acid sequence selected from the group consisting of SEQ ID NOs: 42, 44, 46, 47, 48, 49, 50 and 51; and

a variable light chain region including an amino acid sequence selected from the group consisting of SEQ ID NOs: 43, 45, 52, 53 and 54.

4. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence selected from the group consisting of SEQ ID NO:47, SEQ ID NO:48, SEQ ID NO:49, SEQ ID NO:50 and SEQ ID NO:51.

5. An antibody complex according to claim 4, wherein the variable light chain region comprises an amino acid sequence selected from the group consisting of SEQ ID NO:52, SEQ ID NO:53, and SEQ ID NO:54.

6. An antibody complex according to 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:47 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:52.

7. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:48 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:54.

8. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:50 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:52.

9. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:51 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:52.

10. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:50 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:53.

11. An antibody complex according to claim 3, wherein the variable heavy chain region comprises an amino acid sequence of SEQ ID NO:51 and the variable light chain region comprises an amino acid sequence of SEQ ID NO:53.

12. An antibody complex according to any of claims 1-11, wherein the isolated antibody further comprises an immunoglobulin domain.

13. An antibody complex according to claim 12, wherein the immunoglobulin domain is selected from the group consisting of IgG-1, IgG-4, and IgGM.

14. An antibody complex according to any of claims 1-13, wherein the antibody is a monoclonal antibody.

15. An antibody complex according to claim 14, wherein the antibody is a $F(ab)'_2$ antibody.

16. An antibody complex according to any of claims 1-15, wherein the sialiac acid-containing molecule comprises a lipid head-group and a sialic acid group.

17. An antibody complex according to claim 16, wherein the lipid head-group is a phospholipid.

18. An antibody complex according to any of claims 1-15, wherein the sialic acid-containing molecule is selected from the group consisting of capsular polysialic acid, sialic acid-containing gangliosides, and colominic acid.

19. The liposome complex of claim 9, wherein the sialic acid-containing molecule is a capsular polysialic acid.

20. A composition comprising an antibody complex according to any of claims 1-19.

21. A composition according to claim 20, further comprising a pharmaceutically acceptable diluent.

22. A composition according to claim 20 or 21, wherein the antibody is present in the composition in an amount effective to treat a disease associated with increased or aberrant soluble Aβ, Aβ fibrils or Aβ plaques when administered to a subject in need thereof.

23. A method for treating a disease associated with increased or aberrant soluble Aβ, Aβ fibrils or Aβ plaques in a subject in need thereof, comprising:

administering an effective amount of the antibody of claim 1 to the subject.

24. A method according to claim 23, wherein the subject is suffering from or at risk of Alzheimer's disease.

25. A method according to claim 23 or 24, wherein the subject is suffering from or at risk of Lewy body dimentia.

26. A method according to any of claims 23-25, wherein the subject is suffering from or at risk of Down's Syndrome.

27. A method according to any of claims 23-26, wherein the subject is suffering from or at risk of cerebral amyloid angiopathy.

28. A method according to any of claims 23-27, wherein administering the antibody to the subject comprises administering the antibody directly to the subject's central nervous system.

29. A method according to claim 28, wherein administering the antibody directly to the subject's central nervous system comprises administering the antibody directly to cerebrospinal fluid of the subject.

30. A method according to any of claims 23-29, wherein the antibody is administered via an infusion device implanted in the subject.

31. A system comprising an implantable infusion device and a composition according to any of claims 20-22, wherein the composition is an injectable composition, wherein the infusion device comprises a reservoir for housing the composition, and wherein the composition is housed in the reservoir.

Figure 1: Light Chain and Heavy Chain Expression Vectors.

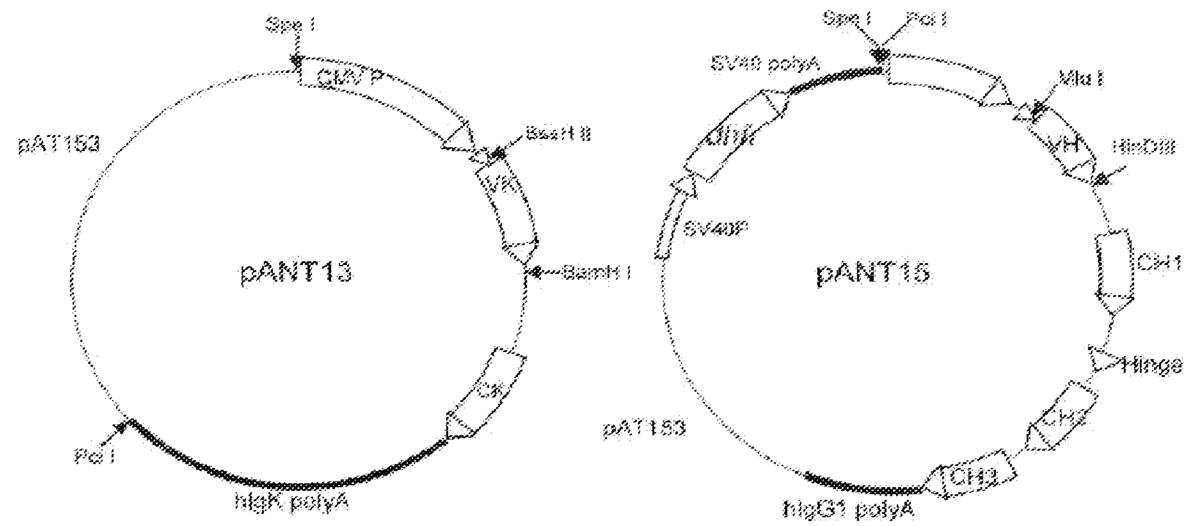


FIGURE 2: SEQUENCES OF MOUSE (CHIMERIC), DEIMMUNIZED ("DeI"), HUMANIZED ("GRAFTED") AND COMPOSITE HUMAN ANTIBODY ("CHAB")VARIANTS OF 6E10 (**=CDRs)**

Heavy Chain Seqs:

		SEQ ID NO:
Mouse:	EVQLQQSGAELVKPGASVKLSCTASGFNIKDTYIHWVKQRPEQGLEWIGRFDPVNVNTRYDSRFRGKATITSDASSNTAYLHLNSLTSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSA	(36)
DeI:	EVQLQQSGAELVKPGASVKVSCTASGFNIKDTYIHWVKQRPEQGLEWIGRFDPVNVNTRYDSRFRGKATITSDASSNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSA	(42)
GRAFT1:	QVQLVQSGAEVKKPGASVKVSCKASGFNIKDTYIHWVRQAPGQGLEWMGRFDPVNVNTRYDSRFRGRVTMTRDTSTSTVYMELSSLRSEDTAVYYCARSYYNGRRRFTYWGQGTLVTVSS	(44)
GRAFT2:	QVQLVQSGAEVKKPGASVKVSCTASGFNIKDTYIHWVRQAPGQGLEWIGRFDPVNVNTRYDSRFRGRVTMTSDASTNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(46)
CHAB1:	EVQLVQSGAELKKPGASVKVSCTASGFNIKDTYIHWVRQAPGQRLEWIGRFDPVNVNTRYDSRFRGRATITSDASTNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(47)
CHAB2:	EVQLVQSGAEVKKPGASVKVSCTASGFNIKDTYIHWVRQARGQRLEWIGRFDPVNVNTRYDSRFRGRATITSDASTNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(48)
CHAB3:	QVQLVQSGAEVKKPGASVKVSCTASGFNIKDTYIHWVRQARGQRLEWIGRFDPVNVNTRYDSRFRGRATITSDASTNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(49)
CHAB4:	QVQLVQSGAEVKKPGASVKVSCTASGFNIKDTYIHWVRQARGQRLEWIGRFDPVNVNTRYDSRFRGRVTITSDASTNTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(50)
CHAB5:	QVQLVQSGAEVKKPGASVKVSCTASGFNIKDTYIHWVRQARGQRLEWIGRFDPVNVNTRYDSRFRGRVTITSDASTSTAYMELSSLRSEDTAVYYCSRSYYNGRRRFTYWGQGTLVTVSS	(51)

Light Chain Seqs:

Mouse:	DIVMTQSPSSLTVTAGEKVALTCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFTGSGSGTFFTLTISSVQAEDLAVYYCQNDYNYPFTFGSGTKLEIK	(37)
DeI:	DIVMTQSPSSLTVTAGEDAALTCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFTGSGSGTFFTLTISSVTAEDLAVYYCQNDYNYPFTFGSGTKLEIK	(43)
GRAFT:	DIVMTQSPDSLAVSLGERATINCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFSGSGSGTDFTLTISSLQAEDVAVYYCQNDYNYPFTFGQGTKLEIK	(45)
CHAB1:	DIVMTQSPDSLTVSLGERATINCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFTGSGSGTFFTLTISSLQAEDVAVYYCQNDYNYPFTFGQGTKLEIK	(52)
CHAB2:	DIVMTQSPSSLTASVGDRVTITCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFTGSGSGTFFTLTISSLQAEDVAVYYCQNDYNYPFTFGQGTKLEIK	(53)
CHAB3:	DIVMTQSPSSLTASVGDRVTITCKASQSLLSSGNQKNYLTWYQQKPGQPPKLLIYWASIRESGVPDRFSGSGSGTDFTLTISSLQAEDVAVYYCQNDYNYPFTFGQGTKLEIK	(54)

FIG. 3: Initial Sequences of Anti-Beta Amyloid (MDT-2007) Heavy and Light Chains

(a) Heavy chain VH1

```
         10        20        30        40        50        60        70        80        90       100
GAGGTTCAGTTGGTGCAGTCTGGGGCAGAGCTTAAGAAGCCAGGGGCCTCAGTCAAGGTGTCCTGTACAGCTTCTGGTTTCAACATTAAAGACACCTATA
 E  V  Q  L  V  Q  S  G  A  E  L  K  K  P  G  A  S  V  K  V  S  C  T  A  S  G  F  N  I  K  D  T  Y
                            10                                     20                                30

        110       120       130       140       150       160       170       180       190       200
TACATTGGGTGAGGCAGGCCCCTGGACAGCGCCTGGAGTGGATTGGAAGGTTTGATCCTGTGAATGTTAATACTAGATATGACTCGCGGTTCCGGGGCAG
I  H  W  V  R  Q  A  P  G  Q  R  L  E  W  I  G  R  F  D  P  V  N  V  N  T  R  Y  D  S  R  F  R  G  R
                  40                                  50    52 A                            60

        210       220       230       240       250       260       270       280       290       300
GGCCACTATAACATCAGACGCATCCACCAATACAGCCTACATGGAGCTCAGCAGCCTGAGATCTGAGGACACTGCCGTCTATTACTGTTCTAGGTCTTAT
  A  T  I  T  S  D  A  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D  T  A  V  Y  Y  C  S  R  S  Y
        70                                    80    82 A  B  C                         90

        310       320       330       340       350       360
TACAACGGTAGAAGACGCTTTACTTACTGGGGCCAAGGGACTCTGGTCACTGTCTCTTCA (SEQ. ID. NO. 55)
 Y  N  G  R  R  R  F  T  Y  W  G  Q  G  T  L  V  T  V  S  S  (SEQ. ID. NO. 47)
      100 A  B  C                             110      113
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 3:

(b) Light Chain Vκ1

```
         10        20        30        40        50        60        70        80        90       100
GACATTGTGATGACACAGTCTCCAGACTCCCTGACTGTGTCACTGGGAGAGAGGGCCACTATCAACTGCAAGGCCAGTCAGAGTCTGTTAAGCAGTGGAA
 D  I  V  M  T  Q  S  P  D  S  L  T  V  S  L  G  E  R  A  T  I  N  C  K  A  S  Q  S  L  L  S  S  G
                            10                            20                         27  A  B  C  D  E  F

        110       120       130       140       150       160       170       180       190       200
ATCAAAAGAACTACTTGACCTGGTACCAACAGAAACCAGGGCAGCCTCCTAAATTGTTGATCTACTGGGCATCTATTAGGGAATCTGGGGTCCCTGATCG
N  Q  K  N  Y  L  T  W  Y  Q  Q  K  P  G  Q  P  P  K  L  L  I  Y  W  A  S  I  R  E  S  G  V  P  D  R
   30                            40                            50                            60

        210       220       230       240       250       260       270       280       290       300
CTTCACAGGCAGTGGATCTGGAACATTTTTCACTCTCACCATCAGTAGTCTGCAGGCTGAAGACGTGGCAGTGTATTACTGTCAGAATGATTATAATTAT
  F  T  G  S  G  S  G  T  F  F  T  L  T  I  S  S  L  Q  A  E  D  V  A  V  Y  Y  C  Q  N  D  Y  N  Y
                          70                            80                            90

        310       320       330
CCATTCACATTCGGCCAGGGGACAAAGTTGGAGATAAAA (SEQ. ID. NO. 56)
 P  F  T  F  G  Q  G  T  K  L  E  I  K  (SEQ. ID. NO. 52)
             100                  106  A
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 4: Composite Human Antibody™ Sequence Variants of Anti-Beta Amyloid (MDT-2007) Heavy Chains

(a) Heavy chain VH2

```
          10        20        30        40        50        60        70        80        90       100
GAGGTTCAGTTGGTGCAGTCTGGGGCAGAGGTGAAGAAGCCAGGGGCCTCAGTCAAGGTGTCCTGTACAGCTTCTGGTTTCAACATTAAAGACACCTATA
 E  V  Q  L  V  Q  S  G  A  E  V  K  K  P  G  A  S  V  K  V  S  C  T  A  S  G  F  N  I  K  D  T  Y
                            10                                     20                                     30

         110       120       130       140       150       160       170       180       190       200
TACATTGGGTGAGGCAGGCCAGGGGACAGCGCCTGGAGTGGATTGGAAGGTTTGATCCTGTGAATGTTAATACTAGATATGACTCGCGGTTCCGGGGCAG
 I  H  W  V  R  Q  A  R  G  Q  R  L  E  W  I  G  R  F  D  P  V  N  V  N  T  R  Y  D  S  R  F  R  G  R
                  40                                      50    52 A                      60

         210       220       230       240       250       260       270       280       290       300
GGCCACTATAACATCAGACGCATCCACCAATACAGCCTACATGGAGCTCAGCAGCCTGAGATCTGAGGACACTGCCGTCTATTACTGTTCTAGGTCTTAT
   A  T  I  T  S  D  A  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D  T  A  V  Y  Y  C  S  R  S  Y
         70                                      80    82  A  B  C                           90

         310       320       330       340       350       360
TACAACGGTAGAAGACGCTTTACTTACTGGGGCCAAGGGACTCTGGTCACTGTCTCTTCA (SEQ. ID. NO. 57)
 Y  N  G  R  R  R  F  T  Y  W  G  Q  G  T  L  V  T  V  S  S  (SEQ. ID. NO. 48)
         100 A  B  C                               110      113
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 4:

(b) Heavy chain VH3

```
         10        20        30        40        50        60        70        80        90       100
CAGGTTCAGTTGGTGCAGTCTGGGGCAGAGGTGAAGAAGCCAGGGGCCTCAGTCAAGGTGTCCTGTACAGCTTCTGGTTTCAACATTAAAGACACCTATA
 Q  V  Q  L  V  Q  S  G  A  E  V  K  K  P  G  A  S  V  K  V  S  C  T  A  S  G  F  N  I  K  D  T  Y
                            10                                      20                                     30

        110       120       130       140       150       160       170       180       190       200
TACATTGGGTGAGGCAGGCCAGGGGACAGCGCCTGGAGTGGATTGGAAGGTTTGATCCTGTGAATGTTAATACTAGATATGACTCGCGGTTCCGGGGCAG
I  H  W  V  R  Q  A  R  G  Q  R  L  E  W  I  G  R  F  D  P  V  N  V  N  T  R  Y  D  S  R  F  R  G  R
                  40                                        50    52  A                       60

        210       220       230       240       250       260       270       280       290       300
GGCCACTATAACATCAGACGCATCCACCAATACAGCCTACATGGAGCTCAGCAGCCTGAGATCTGAGGACACTGCCGTCTATTACTGTTCTAGGTCTTAT
  A  T  I  T  S  D  A  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D  T  A  V  Y  Y  C  S  R  S  Y
           70                                     80    82  A  B  C                       90

        310       320       330       340       350       360
TACAACGGTAGAAGACGCTTTACTTACTGGGGCCAAGGGACTCTGGTCACTGTCTCTTCA (SEQ. ID. NO. 58)
 Y  N  G  R  R  R  F  T  Y  W  G  Q  G  T  L  V  T  V  S  S  (SEQ. ID. NO. 49)
       100  A  B  C                                110       113
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 4:

(c) Heavy chain VH4

```
         10        20        30        40        50        60        70        80        90       100
CAGGTTCAGTTGGTGCAGTCTGGGGCAGAGGTGAAGAAGCCAGGGGCCTCAGTCAAGGTGTCCTGTACAGCTTCTGGTTTCAACATTAAAGACACCTATA
 Q  V  Q  L  V  Q  S  G  A  E  V  K  K  P  G  A  S  V  K  V  S  C  T  A  S  G  F  N  I  K  D  T  Y
                            10                                     20                                     30

        110       120       130       140       150       160       170       180       190       200
TACATTGGGTGAGGCAGGCCAGGGGACAGCGCCTGGAGTGGATTGGAAGGTTTGATCCTGTGAATGTTAATACTAGATATGACTCGCGGTTCCGGGGCAG
I  H  W  V  R  Q  A  R  G  Q  R  L  E  W  I  G  R  F  D  P  V  N  V  N  T  R  Y  D  S  R  F  R  G  R
                 40                                50    52  A                    60

        210       220       230       240       250       260       270       280       290       300
GGTGACTATAACATCAGACGCATCCACCAATACAGCCTACATGGAGCTCAGCAGCCTGAGATCTGAGGACACTGCCGTCTATTACTGTTCTAGGTCTTAT
  V  T  I  T  S  D  A  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D  T  A  V  Y  Y  C  S  R  S  Y
           70                                  80    82  A  B  C                         90

        310       320       330       340       350       360
TACAACGGTAGAAGACGCTTTACTTACTGGGGCCAAGGGACTCTGGTCACTGTCTCTTCA (SEQ. ID. NO. 59)
 Y  N  G  R  R  R  F  T  Y  W  G  Q  G  T  L  V  T  V  S  S   (SEQ. ID. NO. 50)
       100  A  B  C                                110      113
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 4:

(d) Heavy chain VH5

```
         10        20        30        40        50        60        70        80        90       100
CAGGTTCAGTTGGTGCAGTCTGGGGCAGAGGTGAAGAAGCCAGGGGCCTCAGTCAAGGTGTCCTGTACAGCTTCTGGTTTCAACATTAAAGACACCTATA
 Q  V  Q  L  V  Q  S  G  A  E  V  K  K  P  G  A  S  V  K  V  S  C  T  A  S  G  F  N  I  K  D  T  Y
                            10                            20                            30

        110       120       130       140       150       160       170       180       190       200
TACATTGGGTGAGGCAGGCCAGGGGACAGCGCCTGGAGTGGATTGGAAGGTTTGATCCTGTGAATGTTAATACTAGATATGACTCGCGGTTCCGGGGCAG
 I  H  W  V  R  Q  A  R  G  Q  R  L  E  W  I  G  R  F  D  P  V  N  V  N  T  R  Y  D  S  R  F  R  G  R
                  40                            50    52  A                       60

        210       220       230       240       250       260       270       280       290       300
GGTGACTATAACATCAGACGCATCCACCAGCACAGCCTACATGGAGCTCAGCAGCCTGAGATCTGAGGACACTGCCGTCTATTACTGTTCTAGGTCTTAT
 V  T  I  T  S  D  A  S  T  S  T  A  Y  M  E  L  S  S  L  R  S  E  D  T  A  V  Y  Y  C  S  R  S  Y
       70                            80    82  A  B  C                       90

        310       320       330       340       350       360
TACAACGGTAGAAGACGCTTTACTTACTGGGGCCAAGGGACTCTGGTCACTGTCTCTTCA (SEQ. ID. NO. 60)
 Y  N  G  R  R  R  F  T  Y  W  G  Q  G  T  L  V  T  V  S  S  (SEQ. ID. NO. 51)
       100  A  B  C                             110      113
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 5: Composite Human Antibody™ Sequence Variants of Anti-Beta Amyloid (MDT-2007) Light Chains

(a) Light chain Vκ2

```
        10        20        30        40        50        60        70        80        90       100
GACATTGTGATGACACAGTCTCCATCCTCCCTGACTGCCTCAGTGGGAGACAGGGTGACTATCACCTGCAAGGCCAGTCAGAGTCTGTTAAGCAGTGGAA
 D  I  V  M  T  Q  S  P  S  S  L  T  A  S  V  G  D  R  V  T  I  T  C  K  A  S  Q  S  L  L  S  S  G
                            10                            20                      27  A  B  C  D  E  F

       110       120       130       140       150       160       170       180       190       200
ATCAAAAGAACTACTTGACCTGGTACCAACAGAAACCAGGGCAGCCTCCTAAATTGTTGATCTACTGGGCATCTATTAGGGAATCTGGGGTCCCTGATCG
N  Q  K  N  Y  L  T  W  Y  Q  Q  K  P  G  Q  P  P  K  L  L  I  Y  W  A  S  I  R  E  S  G  V  P  D  R
   30                            40                            50                            60

       210       220       230       240       250       260       270       280       290       300
CTTCACAGGCAGTGGATCTGGAACATTTTTCACTCTCACCATCAGTAGTCTGCAGGCTGAAGACGTGGCAGTGTATTACTGTCAGAATGATTATAATTAT
  F  T  G  S  G  S  G  T  F  F  T  L  T  I  S  S  L  Q  A  E  D  V  A  V  Y  Y  C  Q  N  D  Y  N  Y
                           70                            80                            90

       310       320       330
CCATTCACATTCGGCCAGGGGACAAAGTTGGAGATAAAA (SEQ. ID. NO. 61)
 P  F  T  F  G  Q  G  T  K  L  E  I  K  (SEQ. ID. NO. 53)
                100               106  A
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

FIG. 5:

(b) Light chain Vκ3

```
        10        20        30        40        50        60        70        80        90       100
GACATTGTGATGACACAGTCTCCATCCTCCCTGACTGCCTCAGTGGGAGACAGGGTGACTATCACCTGCAAGGCCAGTCAGAGTCTGTTAAGCAGTGGAA
 D  I  V  M  T  Q  S  P  S  S  L  T  A  S  V  G  D  R  V  T  I  T  C  K  A  S  Q  S  L  L  S  S  G
                            10                                      20                   27  A  B  C  D  E  F

       110       120       130       140       150       160       170       180       190       200
ATCAAAAGAACTACTTGACCTGGTACCAACAGAAACCAGGGCAGCCTCCTAAATTGTTGATCTACTGGGCATCTATTAGGGAATCTGGGGTCCCTGATCG
 N  Q  K  N  Y  L  T  W  Y  Q  Q  K  P  G  Q  P  P  K  L  L  I  Y  W  A  S  I  R  E  S  G  V  P  D  R
    30                                      40                                      50                                     60

       210       220       230       240       250       260       270       280       290       300
CTTCAGCGGCAGTGGATCTGGAACAGACTTCACTCTCACCATCAGTAGTCTGCAGGCTGAAGACGTGGCAGTGTATTACTGTCAGAATGATTATAATTAT
 F  S  G  S  G  S  G  T  D  F  T  L  T  I  S  S  L  Q  A  E  D  V  A  V  Y  Y  C  Q  N  D  Y  N  Y
                         70                                      80                                      90

       310       320       330
CCATTCACATTCGGCCAGGGGACAAAGTTGGAGATAAAA (SEQ. ID. NO. 62)
 P  F  T  F  G  Q  G  T  K  L  E  I  K  (SEQ. ID. NO. 54)
                100                    106  A
```

CDR definitions and protein sequence numbering according to Kabat. CDR nucleotide and protein sequences are underlined

Differences from murine reference sequence are overlined

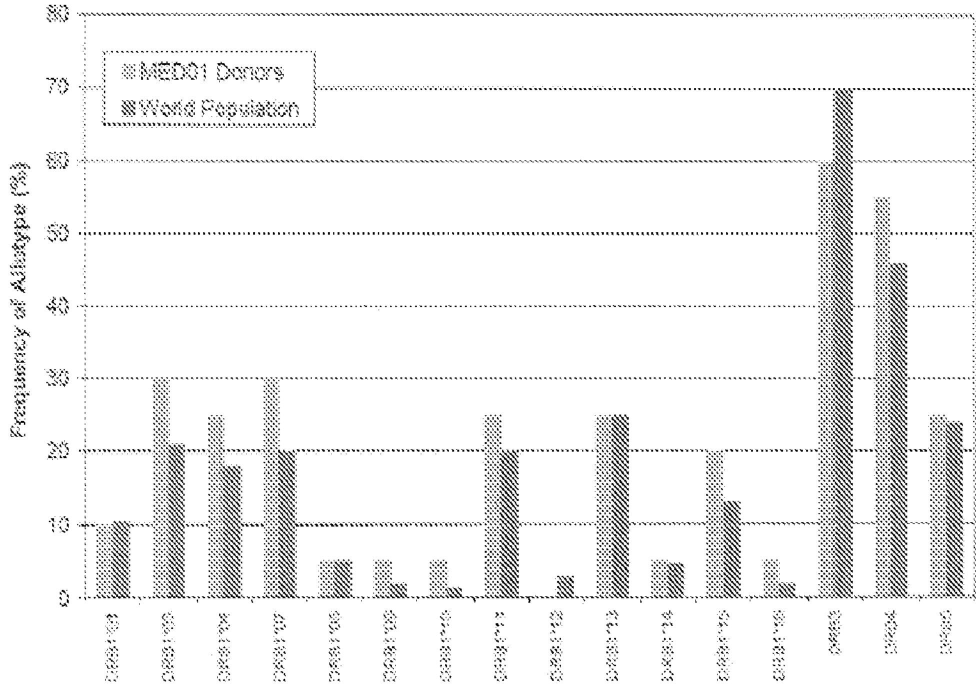
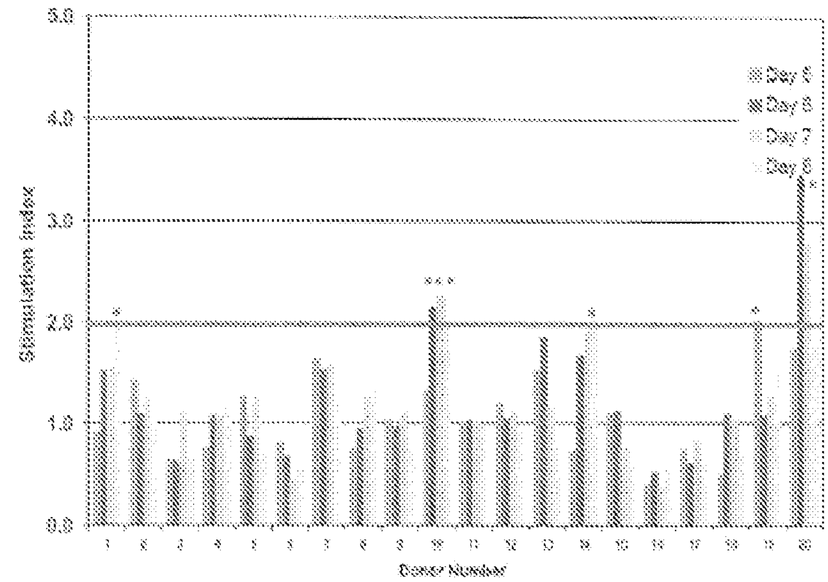


FIG. 6: Frequency of HLA class II allotypes in the world population and the study population

(a)



(b)

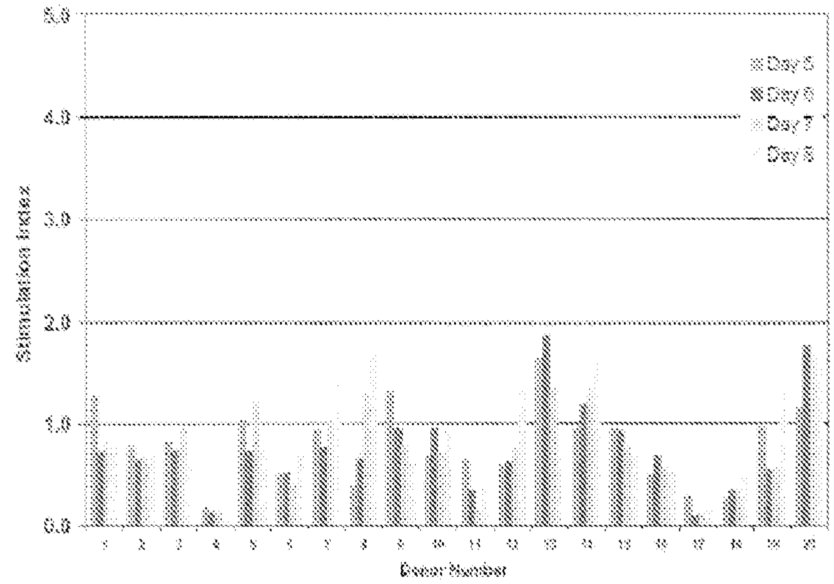


FIG. 7: MDT-2007 and chimeric antibodies were tested in EpiScreen™ time course T cell assays using PBMC from 20 donors.

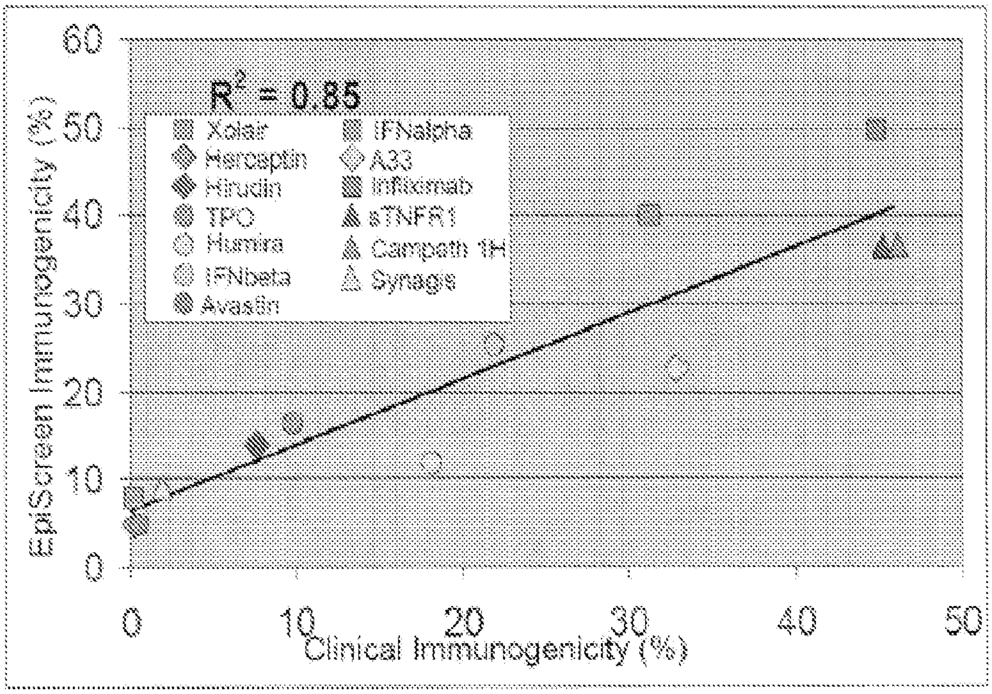


FIG. 8: Comparison of immunogencity predicted using EpiScreen Technology and immunogenicity observed in a clinical setting.

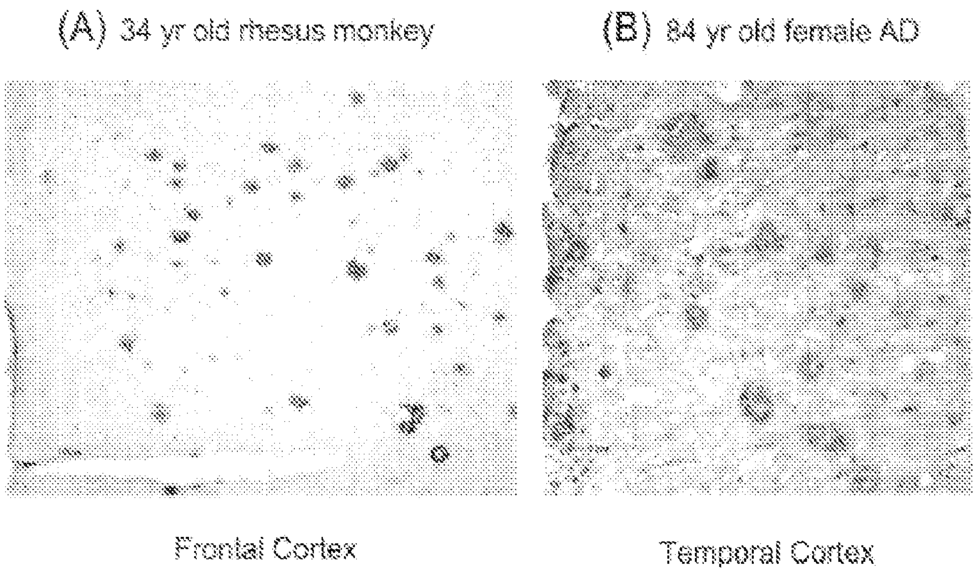


FIG. 9: MDT-2007 Amyloid Positive Plaques in the Aged Rhesus Monkey and AD Cortex

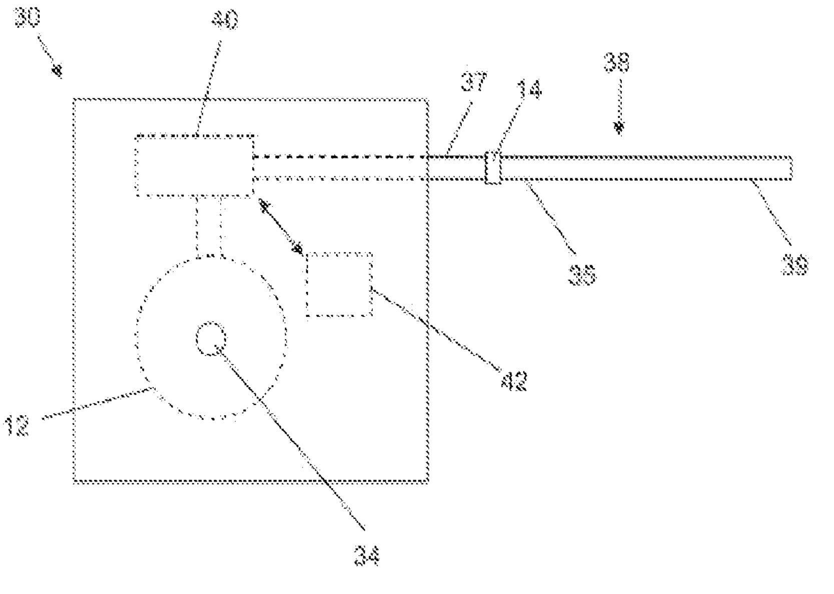


FIG. 10

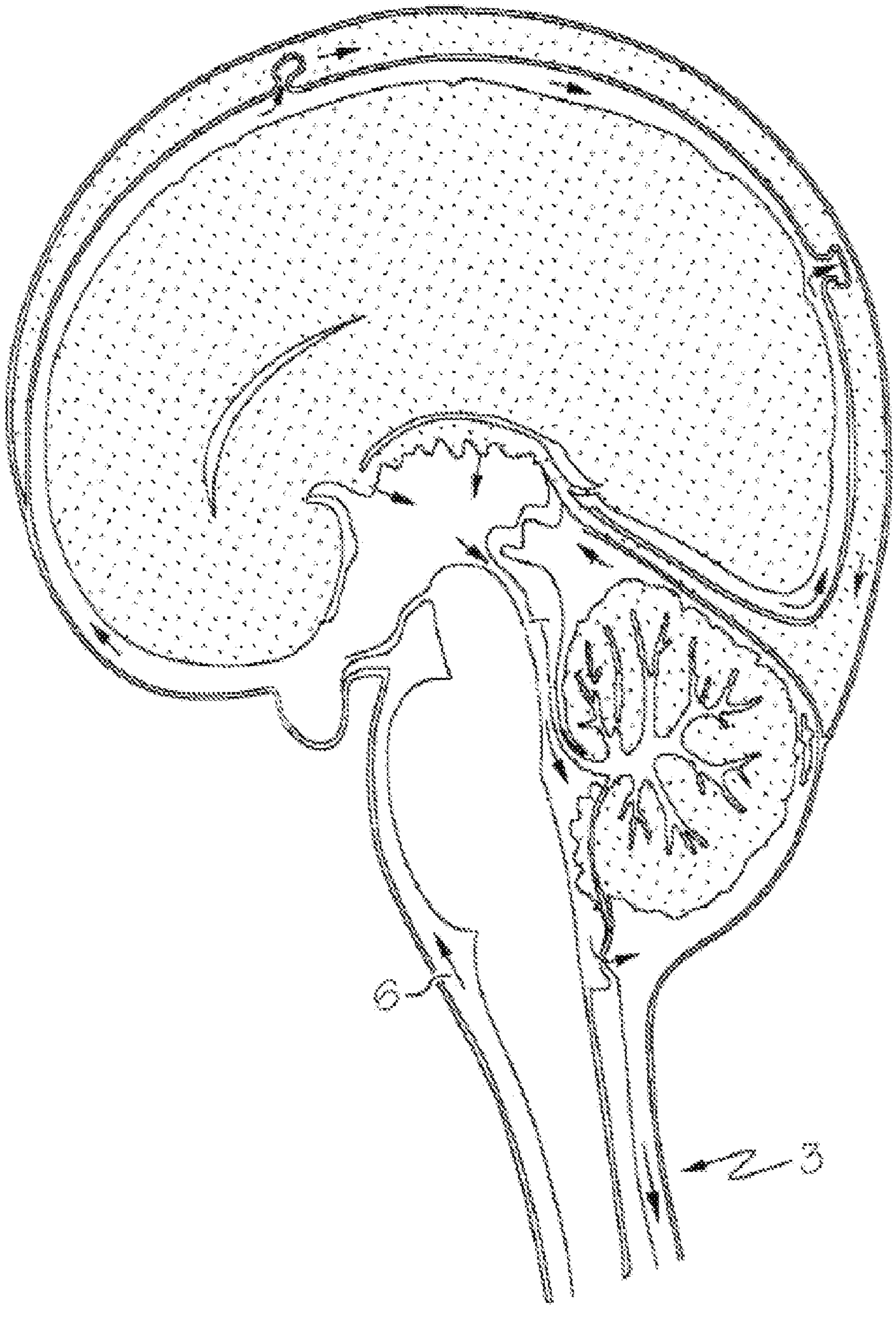


FIG. 11

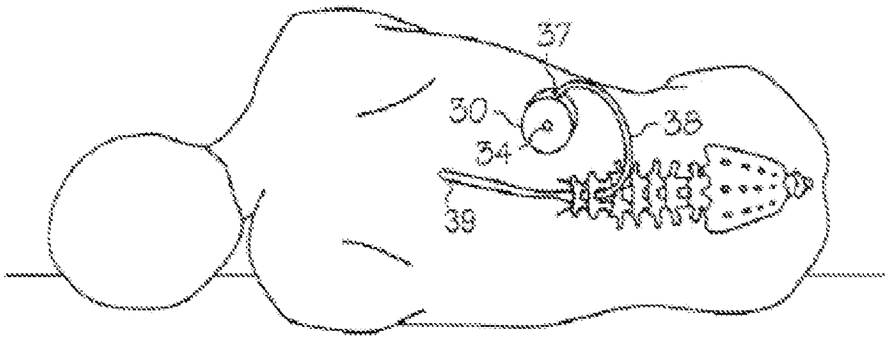


FIG. 12

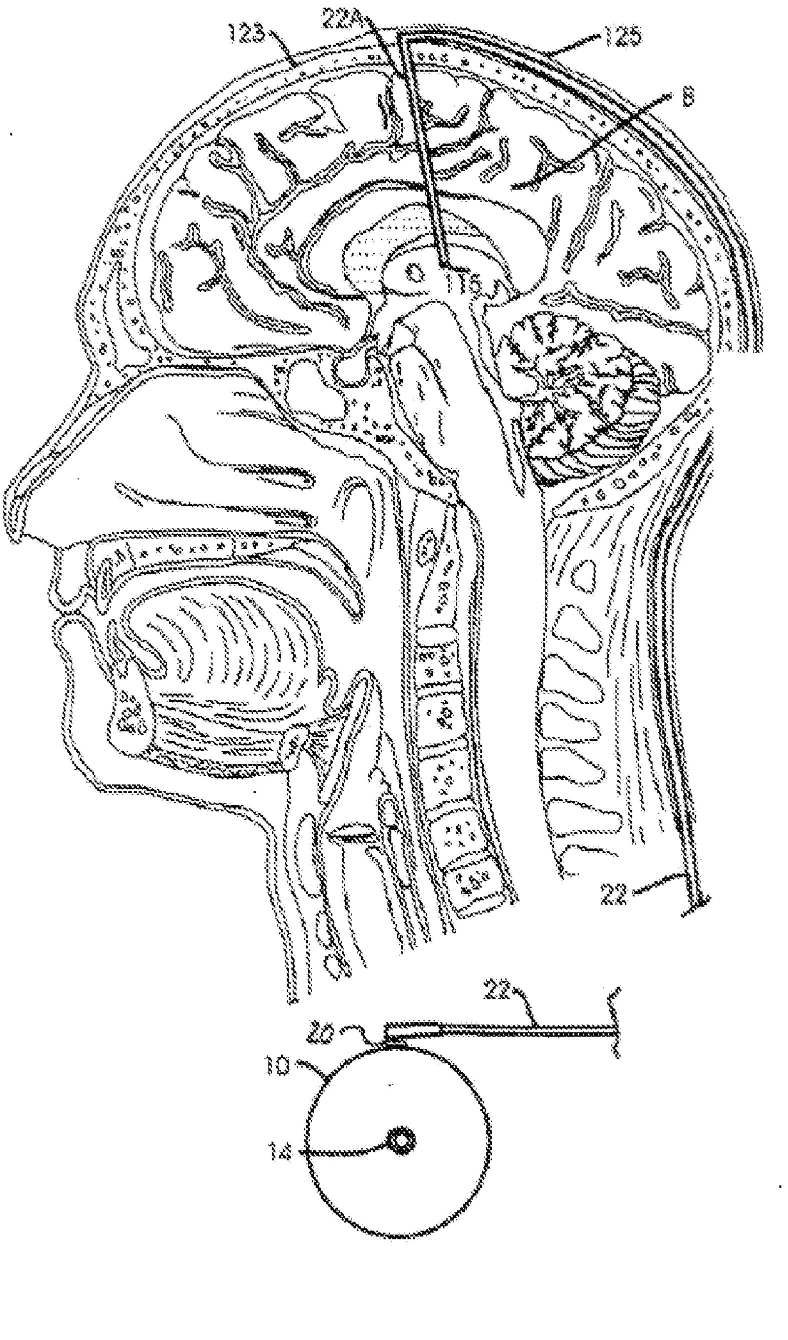


FIG. 13

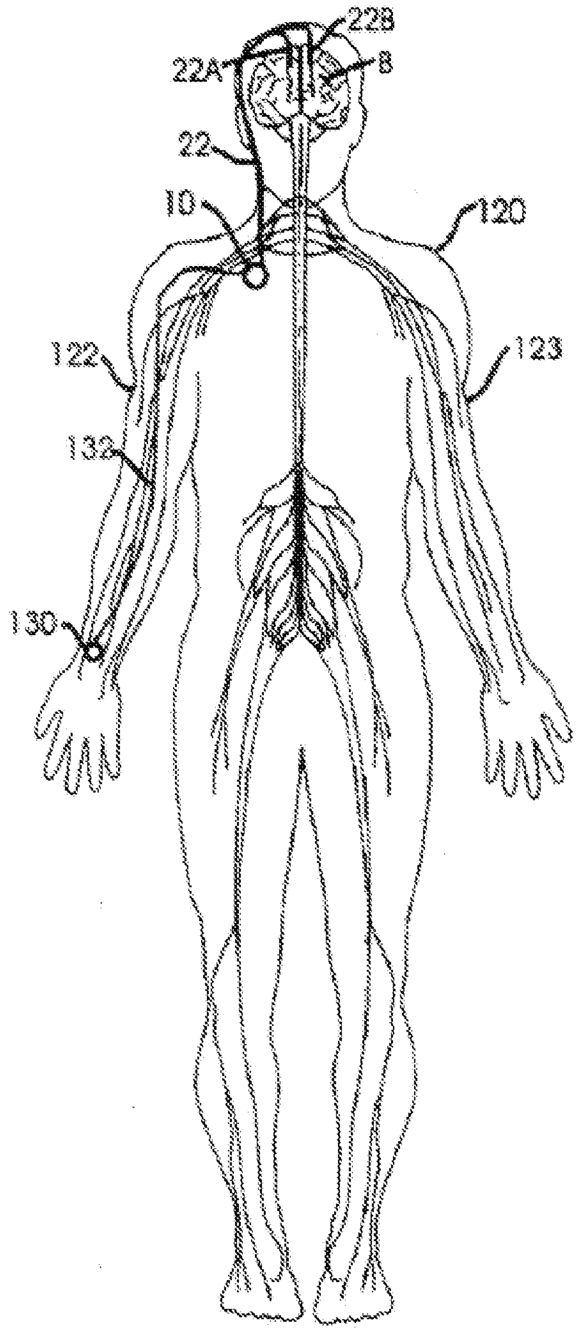


FIG. 14

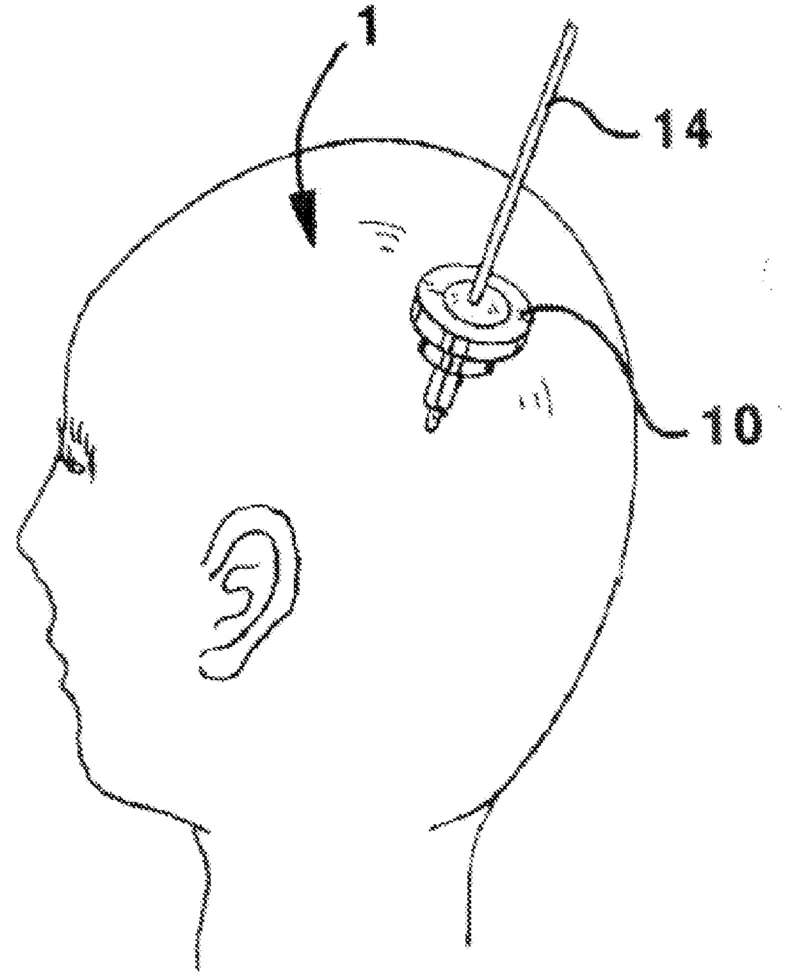


FIG. 15

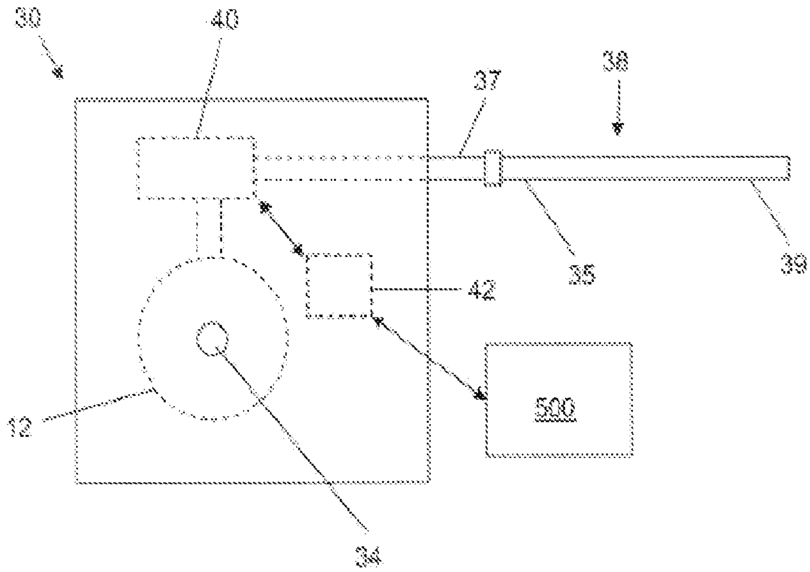


FIG. 16

Conjugation (shift by 10-30KDa)

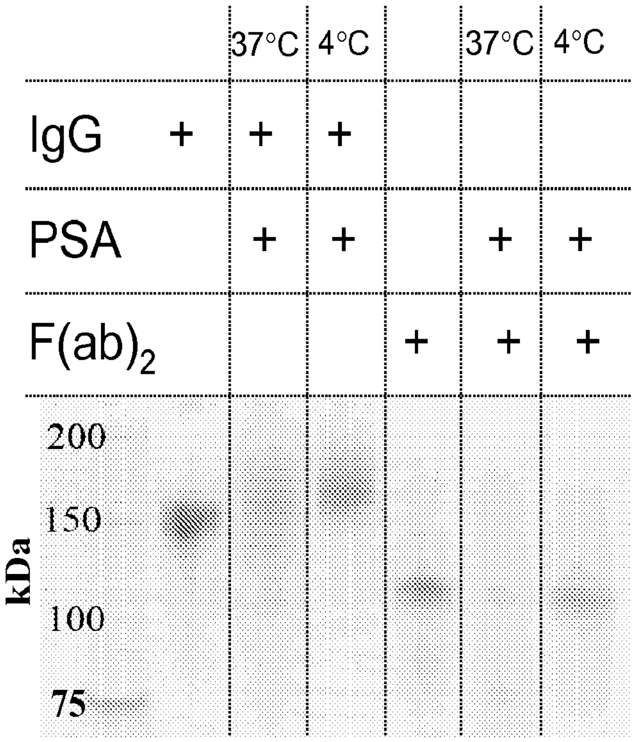


FIG. 17

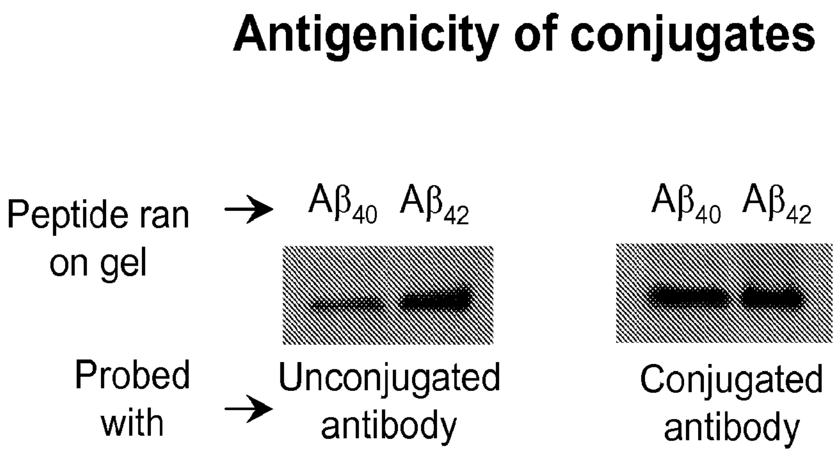

Antigenicity of conjugates
Peptide ran on gel
Aβ40 Aβ42
Aβ40 Aβ42
Probed with
Unconjugated antibody
Conjugated antibody

FIG. 18

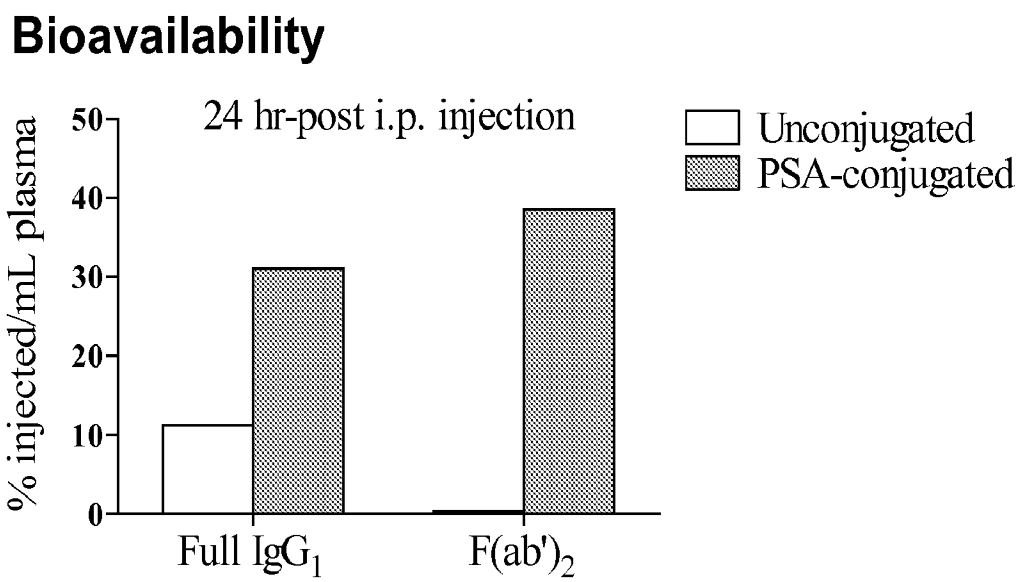

Bioavailability
24 hr-post i.p. injection
% injected/mL plasma
50
40
30
20
10
0
Full IgG1
F(ab')2
Unconjugated
PSA-conjugated

FIG. 19

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/036305

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K16/18 G01N33/68 A61K39/395 A61K31/7012 A61P25/28
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K G01N A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BIOSIS, Sequence Search, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2009/070648 A2 (MEDTRONIC INC [US]; SHAFER LISA LYNN [US]; CARR FRANCIS JOSESPH [GB];) 4 June 2009 (2009-06-04) the whole document in particular; paragraphs [0005] - [0010], [0045] - [0053], [0083] - [0098], [0107] - [0108] claims 1-38; figures 1-16; examples 1-7	1-31
X	WO 2007/113172 A2 (GLAXO GROUP LTD [GB]; BURBIDGE STEPHEN ANTHONY [GB]; ELLIS JONATHAN HE) 11 October 2007 (2007-10-11)	1,2, 12-31
Y	the whole document in particular; page 3, line 33 - page 8, line 43 page 17, lines 17-39 page 23, line 21 - page 24, line 32 claims 1-20; examples	3-11

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 September 2010	06/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ferreira, Roger

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/036305

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2007/064972 A2 (ABBOTT LAB [US]; ABBOTT GMBH & CO KG [DE]; LABKVOSKY BORIS [US]; BARGH) 7 June 2007 (2007-06-07) the whole document in particular; page 3, line 5 - page 8, line 30 page 44, line 18 - page 46, line 27 page 60, line 27 - page 64, line 25 claims 1-55; figures 1-10; examples I-VI -----	1,2, 12-31 3-11
A	HOLT L J ET AL: "Domain antibodies: proteins for therapy" TRENDS IN BIOTECHNOLOGY, ELSEVIER PUBLICATIONS, CAMBRIDGE, GB LNKD- DOI:10.1016/J.TIBTECH.2003.08.007, vol. 21, no. 11, 1 November 2003 (2003-11-01), pages 484-490, XP004467495 ISSN: 0167-7799 the whole document -----	1-31
A	DAVIES J ET AL: "Affinity improvement of single antibody VH domains: residues in all three hypervariable regions affect antigen binding" IMMUNOTECHNOLOGY, ELSEVIER SCIENCE PUBLISHERS BV, NL LNKD- DOI:10.1016/S1380-2933(96)00045-0, vol. 2, no. 3, 1 September 1996 (1996-09-01), pages 169-179, XP004070292 ISSN: 1380-2933 the whole document -----	1-31
A	WO 2008/033253 A2 (MEDTRONIC INC [US]; THAKKER DEEPAK [US]; BENZ MICHAEL ERIC [US]) 20 March 2008 (2008-03-20) the whole document -----	1-31
A	MOHAJERI M HASAN ET AL: "Assessment of the bioactivity of antibodies against beta-amyloid peptide in vitro and in vivo" NEURODEGENERATIVE DISEASES, KARGER AG, BASEL, CH LNKD- DOI:10.1159/000080981, vol. 1, no. 4-5, 1 January 2004 (2004-01-01), pages 160-167, XP002501119 ISSN: 1660-2854 the whole document -----	1-31

-/--

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/036305

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LIU RUITIAN ET AL: "Single chain variable fragments against beta-amyloid (Abeta) can inhibit Abeta aggregation and prevent Abeta-induced neurotoxicity" BIOCHEMISTRY, AMERICAN CHEMICAL SOCIETY, US LNKD- DOI:10.1021/BI0499330, vol. 43, no. 22, 12 May 2004 (2004-05-12), pages 6959-6967, XP002395890 ISSN: 0006-2960 the whole document	1-31
A	SOLOMON BEKA: "Beta-amyloidbased immunotherapy as a treatment of Alzheimers disease" DRUGS OF TODAY, PROUS SCIENCE, ES LNKD- DOI:10.1358/DOT.2007.43.5.1062670, vol. 43, no. 5, 1 May 2007 (2007-05-01), pages 333-342, XP002503512 ISSN: 1699-3993 the whole document	1-31
A	RAJU T SHANTHA ET AL: "Glycoengineering of therapeutic glycoproteins: In vitro galactosylation and sialylation of glycoproteins with terminal N-acetylglucosamine and galactose residues" BIOCHEMISTRY, AMERICAN CHEMICAL SOCIETY, US LNKD- DOI:10.1021/BI010475I, vol. 40, no. 30, 31 July 2001 (2001-07-31), pages 8868-8876, XP002461128 ISSN: 0006-2960 the whole document	1-31
A	CONSTANTINOU ANTONY ET AL: "Modulation of antibody pharmacokinetics by chemical polysialylation." BIOCONJUGATE CHEMISTRY MAR 2008 LNKD- PUBMED:18307285, vol. 19, no. 3, March 2008 (2008-03), pages 643-650, XP002599149 ISSN: 1043-1802 the whole document	1-31
A	GREGORIADIS ET AL: "Improving the therapeutic efficacy of peptides and proteins: A role for polysialic acids" INTERNATIONAL JOURNAL OF PHARMACEUTICS, ELSEVIER BV, NL LNKD- DOI:10.1016/J.IJPHARM.2005.06.007, vol. 300, no. 1-2, 26 August 2005 (2005-08-26), pages 125-130, XP005013268 ISSN: 0378-5173 the whole document	1-31

-/--

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/036305

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GREGORIADIS G ET AL: "Polysialic acids: Potential in improving the stability and pharmacokinetics of proteins and other therapeutics" CMLS CELLULAR AND MOLECULAR LIFE SCIENCES, BIRKHAUSER VERLAG, HEIDELBERG, DE, vol. 57, no. 13-14, 1 December 2000 (2000-12-01), pages 1964-1969, XP002195628 ISSN: 1420-682X the whole document -----	1-31
A,P	CONSTANTINOU A ET AL: "Site-specific polysialylation of an antitumor single-chain Fv fragment." BIOCONJUGATE CHEMISTRY 20 MAY 2009 LNKD- PUBMED:19402707, vol. 20, no. 5, 20 May 2009 (2009-05-20), pages 924-931, XP002599150 ISSN: 1520-4812 the whole document -----	1-31

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/036305

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009070648 A2	04-06-2009	EP 2222700 A2	01-09-2010
WO 2007113172 A2	11-10-2007	AR 060332 A1	11-06-2008
		AT 451392 T	15-12-2009
		AU 2007233831 A1	11-10-2007
		CA 2647808 A1	11-10-2007
		CN 101415729 A	22-04-2009
		DK 1996621 T3	19-04-2010
		EA 200801842 A1	27-02-2009
		EP 1996621 A2	03-12-2008
		EP 2177536 A1	21-04-2010
		ES 2338179 T3	04-05-2010
		HK 1122311 A1	23-07-2010
		HR 20100115 T1	30-04-2010
		JP 2009531380 T	03-09-2009
		KR 20080113273 A	29-12-2008
		PT 1996621 E	08-03-2010
		SI 1996621 T1	30-04-2010
		ZA 200807911 A	25-11-2009
WO 2007064972 A2	07-06-2007	AU 2006320392 A1	07-06-2007
		CA 2631195 A1	07-06-2007
		CN 101506236 A	12-08-2009
		EP 1976877 A2	08-10-2008
		JP 2009519012 T	14-05-2009
		KR 20080090407 A	08-10-2008
		US 2009238831 A1	24-09-2009
		ZA 200804686 A	28-10-2009
WO 2008033253 A2	20-03-2008	EP 2068832 A2	17-06-2009