

ANTI-ABETA ANTIBODIES**RELATED APPLICATION**

[001] This application claims the benefit of U.S. Provisional Patent Application No. 63/055,813, filed July 23, 2020, U.S. Provisional Patent Application No. 63/086,589, filed October 1, 2020, U.S. Provisional Patent Application No. 63/187,379, filed May 11, 2021, and U.S. Provisional Patent Application No. 63/219,611, filed July 8, 2021, all of which are incorporated by reference herein in their entirety.

SEQUENCE LISTING STATEMENT

[002] A computer readable form of the Sequence Listing is filed with this application by electronic submission and is incorporated into this application by reference in its entirety. The Sequence Listing is contained in the file created on July 22, 2021, having the file name "20-1030-WO_Sequence-Listing_ST25.txt" and is 155 kb in size.

FIELD

[003] The present disclosure relates to anti-Amyloid beta (A β) antibodies as well as compositions and methods of their use.

BACKGROUND

[004] Alzheimer's disease (AD) is a progressive disease resulting in senile dementia. The disease is generally categorized as late onset, which occurs in old age (65+years) and early onset, which develops well before the senile period, i.e., between 35 and 60 years. Disease pathology appears to be the same for both types of disease, but abnormalities tend to be more severe and widespread in cases beginning at an earlier age. The disease is characterized by at least two types of lesions in the brain, neurofibrillary tangles and senile plaques. Neurofibrillary tangles are intracellular deposits of microtubule associated tau protein consisting of two filaments twisted about each other in pairs. Senile plaques (i.e., amyloid plaques) are areas of disorganized neuropil up to 150 μ m across with extracellular amyloid deposits at the center which are visible by microscopic analysis of sections of brain tissue. The accumulation of amyloid plaques within the brain is also associated with Down's syndrome and other cognitive disorders.

[005] The principal constituent of the plaques is a peptide termed A β (Abeta) or β -amyloid peptide. A β peptide is a 4-kDa internal fragment of 39-43 amino acids of a larger

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

SUMMARY

[006] The present disclosure relates to antibodies (and antibody fragments) that specifically bind to A β , methods of producing such antibodies and antibody fragments and associated nucleic acids, methods of treatment of patients with A β -related neurological disorders, pharmaceutical formulations and compositions of antibodies that show high affinity binding to A β for prophylactic and/or therapeutic use to, for example, treat, reduce the risk of or delay the onset of amyloidogenic disease, prevent, reduce or inhibit markers of amyloidogenic disease, e.g., A β plaques, and improve cognition. The present disclosure further relates to methods of detecting amyloid plaques and measuring the efficacy of treatment in patients being treated for amyloidogenic disease. The disclosure is based, at least in part, on the identification and characterization of monoclonal antibodies that specifically bind to A β peptide and are effective at reducing plaque burden and neutralizing soluble A β species associated with amyloidogenic disorders.

[007] In various aspects, the disclosure are directed to antibodies or fragments thereof that that specifically binds to A β peptide. The antibodies and fragments include a heavy chain variable region including heavy chain CDR1, CDR2 and CDR3 and a light chain variable region including light chain CDR1, CDR2 and CDR3, wherein the heavy chain CDR1, CDR2 and CDR3 and the light chain CDR1, CDR2 and CDR3 are as shown for one of the antibodies in Table 1. In addition, the antibodies or fragments or fragments of the disclosure may have a heavy chain variable region that is as shown for one of the antibodies in Table 1 and may have a light chain variable region that is shown for one of the antibodies in Table 1.

[008] In various embodiments of the disclosure, the antibodies and fragments thereof include a heavy chain variable region including heavy chain CDR1, CDR2 and CDR3 and a light chain variable region including light chain CDR1, CDR2 and CDR3, wherein

heavy chain CDR1 includes one of SEQ ID NO: 16, 19, or 20,

heavy chain CDR2 includes one of SEQ ID NO: 20, 21, 22 or 23,

heavy chain CDR3 includes one of SEQ ID NO: 18, 24, or 25,

light chain CDR1 includes one of SEQ ID NO: 26, 29, 31, or 32,

light chain CDR2 includes one of SEQ ID NO: 33, 34, 35 or 36, and

light chain CDR3 includes one of SEQ ID NO: 28, 38 or 39.

[009] The antibody or fragment thereof of the disclosure may include a heavy chain variable region, excluding the CDRs, that is at least 95% or 98% identical an amino acid sequence selected from SEQ ID NO: 3, 4, 5, 6, and 7, and the light chain variable region, excluding the CDRs, that is at least 95% or 98% identical an amino acid sequence selected from SEQ ID NO: 8, 9, 10, 11, 12, 13, 14, and 15. In addition, the heavy chain variable region may be selected from SEQ ID NOs: 3, 4, 5, 6, and 7, and the light chain variable region may be selected from SEQ ID NO: 8, 9, 10, 11, 12, 13, 14 and 15.

[0010] In further embodiments, the disclosure is directed to an antibody or fragment thereof that specifically binds to A β peptide, including a heavy chain variable region including heavy chain CDR1, CDR2 and CDR3 and a light chain variable region including light chain CDR1, CDR2 and CDR3, having the following amino acid sequences:

heavy chain CDR1 includes amino acid sequence GFTFSNX₁GMS, wherein X₁ is Y or F (SEQ ID NO: 88);

heavy chain CDR2 includes amino acid sequence SX₁RSGSGRTYYSDNVKG, wherein X₁ is I or V (SEQ ID NO: 89);

heavy chain CDR3 includes amino acid sequence YDHYX₁GX₂SDY, wherein X₁ is S or T and X₂ is S or T (SEQ ID NO: 90);

light chain CDR1 includes amino acid sequence KSSQSLLDYDGKTYLN (SEQ ID NO: 91);

light chain CDR2 includes amino acid sequence $X_1VX_2NRDX_3$, wherein X_1 is K or R, X_2 is S or T, and X_3 is S or T (SEQ ID NO: 92).

light chain CDR3 includes amino acid sequence WQGTHFPRX₁, wherein X_1 is S or T (SEQ ID NO: 93).

[0011] In addition, the light chain CDR3 may be WQGTHFPRX₁FX₂, wherein X_1 is S or T and X_2 is F or Y (SEQ ID NO: 94).

[0012] Still further, embodiments of the disclosure are directed to an antibody or fragment thereof that specifically binds to A β peptide, including a heavy chain variable region including heavy chain CDR1, CDR2 and CDR3 and a light chain variable region including light chain CDR1, CDR2 and CDR3, having the following amino acid sequences:

heavy chain CDR1 includes amino acid sequence GFTFX₁NX₂GMS, wherein X_1 is S or A, and X_2 is Y or F (SEQ ID NO: 95);

heavy chain CDR2 includes amino acid sequence SX₁RSGX₂X₃RTYYSDNVKG, wherein X_1 is I or V, X_2 is S or G and X_3 is S or G (SEQ ID NO: 96);

heavy chain CDR3 includes amino acid sequence YDHYX₁GX₂SDY, wherein X_1 is S or T and X_2 is S or T (SEQ ID NO: 90);

light chain CDR1 includes amino acid sequence X₁SSQSLX₂DX₃DGKTYLN, wherein X_1 is K or R, X_2 is V, M or L, and X_3 is Y, T or S (SEQ ID NO: 97);

light chain CDR2 includes amino acid sequence $X_1VX_2NRX_3X_4$, wherein X_1 is K or R, X_2 is S or T, and X_3 is E or D, and X_4 is S or T (SEQ ID NO: 98).

light chain CDR3 includes amino acid sequence WQGX₁HFPRX₂, wherein X_1 is S or T, and X_2 is S or T (SEQ ID NO: 99).

[0013] The light chain CDR3 may also include WQGTHFPRX₁FX₂X₃, wherein X_1 is S or T, X_2 is S or T and X_3 is F or Y (SEQ ID NO: 100).

[0014] In further aspects of the disclosure, the antibody or fragment thereof of one is humanized, is human IgG1, or may be a full antibody, a chimeric antibody, a CDR-grafted antibody, or a recombinant antibody. Antibody fragments may include a Fab, Fab', F(ab')₂, Fabc, or Fv.

[0015] Still further, the antibody or fragment of the disclosure may include a heavy chain constant region including an amino acid sequence at least 95% identical to SEQ ID NO:40, and may include a light chain constant region including an amino acid sequence at least 95% identical to SEQ ID NO:41. The antibody or fragment may specifically bind to an epitope having an amino acid sequence including three or more amino acid positions from amino acids 1-7 of A β .

[0016] In additional aspects, the disclosure is directed to a nucleic acid encoding the heavy chain and/or light chain of an antibody as described herein.

[0017] The disclosure is also directed to a pharmaceutical composition including an antibody or fragment thereof as described herein.

[0018] In various embodiments, the disclosure is directed to a method of producing the antibody or fragment thereof as described herein. The method may include (a) culturing cells transformed with nucleic acids encoding the heavy and light chains of the antibody or fragment thereof, so that the cells secrete the antibody or fragment thereof; and (b) purifying the antibody or fragment thereof from cell culture.

[0019] In another aspect, the disclosure is directed to a method of producing a cell line producing the antibody or fragment thereof as described herein. The method may include (a) introducing a vector encoding heavy and light chains of the antibody or fragment thereof and a selectable marker into cells; (b) propagating the cells under conditions to select for cells having increased copy number of the vector; (c) isolating single cells from the selected cells; and (d) banking cells cloned from a single cell selected based on yield of antibody or a fragment thereof. The method may also include propagating the cells under selective conditions and screening for cell lines naturally expressing and secreting at least 100 mg/L/10⁶ cells/24 h.

[0020] Additional aspects of the addition include methods of preventing or treating amyloidogenic disease in a patient. The methods include administering an effective dosage of the antibody or fragment as described herein to the patient. The amyloidogenic disease may be systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.

[0021] When the amyloidogenic disease, the methods of the disclosure may include administering to a patient having the disease the antibody or fragment thereof in a regime effective to treat the disease. In addition, the methods of the disclosure include reducing the risk or delaying the outset of Alzheimer's disease in a patient whose risk of the disease has been determined from a genetic or biochemical marker. The method includes administering to a patient having the disease the antibody or fragment thereof as described herein in a regime effective to reduce the risk or delay the outset of the disease.

[0022] Still further, the disclosure is directed to a method for effecting improvement of cognition in a subject having a condition or disease related amyloidogenic disease. The method include including administering to the subject an effective amount of the antibody or fragment thereof as described herein. The amyloidogenic disease may be systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.

[0023] Still further, the disclosure is directed to a method for treating Down's syndrome or clinical or pre-clinical Alzheimer's disease in a human subject. The method include including administering to the subject an effective amount of the antibody or fragment thereof as described herein.

[0024] Method of the disclosure also include one or more of inhibiting the formation of amyloid plaque in a human subject, reduce amyloid plaque in the brain of a human subject, inhibiting or reducing amyloid plaque in a subject having or at risk of developing an amyloidogenic disease. The methods include including administering to the subject an effective amount of the antibody or fragment thereof as described herein. In each of these methods, the amyloid plaque may include $A\beta_{1-42}$, pyroglutamate species of $A\beta$ (e.g., $A\beta_{pE3-42}$), or a combination thereof.

[0025] In yet another aspect, the disclosure is directed to a method of detecting amyloid plaques in a subject having or at risk of an amyloidogenic disease. The method includes administering to a subject an antibody or fragment as described herein, and detecting the antibody or fragment thereof bound to $A\beta$ in the subject. The amyloidogenic disease is systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment. In the detection methods, the antibody or fragment thereof may be labeled, for

example the with a fluorescent label, a paramagnetic label, or a radioactive label. The radioactive label may be detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).

[0026] A method of measuring efficacy of treatment in a subject being treated for an amyloidogenic disease, including:

(a) measuring a first level of amyloid plaque in the subject prior to treatment by administering to a subject an antibody or fragment thereof of any one of claims 1-18, and detecting a first amount of the antibody or fragment thereof bound to A β in the subject,

(b) administering the treatment to the subject,

(c) measuring a second level of amyloid plaque in the subject after treatment by administering to a subject the antibody or fragment thereof, and detecting the antibody or fragment thereof bound to A β in the subject,

wherein a decrease in the level of amyloid plaque indicates a positive response to treatment.

[0027] Still further, other aspects of the disclosure include a method of measuring efficacy of treatment in a subject being treated for an amyloidogenic disease. The methods includes (a) measuring a first level of amyloid plaque in the subject prior to treatment by administering to a subject an antibody or fragment thereof as described herein, and detecting a first amount of antibody or fragment thereof bound to A β in the subject, (b) administering the treatment to the subject, (c) measuring a second level of amyloid plaque in the subject after treatment by administering to a subject the antibody or fragment thereof, and detecting a second amount of antibody or fragment thereof bound to A β in the subject. No change in the level of amyloid plaque or a small increase in amyloid plaque indicates a positive response to treatment.

[0028] The methods of the disclosure also include reducing, clearing, or promoting clearance of A β , or reducing or inhibiting A β accumulation or aggregation, in a human subject. Such methods include administering to the subject an effective regime of the antibody or fragment thereof as described herein. The A β may be present in the subject's brain tissue.

[0029] The methods of the disclosure also include reducing, promoting clearance, or clearing of A β in brain tissue of a subject having or at risk of developing an amyloidogenic

disease. Such methods include administering to the subject an effective regime of the antibody or fragment thereof as described herein.

[0030] The methods of the disclosure also include inhibiting or reducing A β accumulation or aggregation in brain tissue of a subject having or at risk of developing an amyloidogenic disease. Such methods include administering to the subject an effective regime of the antibody or fragment thereof as described herein. .

[0031] A method of inhibiting A β accumulation or aggregation in brain tissue of a subject having or at risk of developing an amyloidogenic disease, including administering to the subject an effective regime of the antibody of any one of claims 1 to 18, thereby inhibiting A β accumulation or aggregation in brain tissue in the subject. The amyloidogenic disease may be systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment. The A β may be A β ₁₋₄₂, pyroglutamate species of A β (e.g., A β _{pE3-42}), or a combination thereof.

[0032] In each of the foregoing methods of the disclosure, the antibody is administered by peripheral administration, which may be intravenous or subcutaneous administration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] **FIG. 1** shows an alignment of three different versions of VL that were designed by incorporating human germline framework residues into bapineuzumab (hBP) VL sequence. Canonical or interface residues were not changed.

[0034] **FIG. 2** shows competitive ELISA assay graphs for 4918, 4917, 4921, 3818, 49human3, 2931 and bapineuzumab control for IC₅₀ ratio determination relative to bapineuzumab (hBP).

[0035] **FIG. 3** shows competitive ELISA assay graphs for 2926, 2831, 2927, 2726, 2731, 2826 and bapineuzumab control for IC₅₀ ratio determination relative to bapineuzumab (hBP).

[0036] **FIG. 4** shows competitive ELISA assay graphs for 2727, 2931 and bapineuzumab control for IC₅₀ ratio determination relative to bapineuzumab (hBP).

[0037] **FIG. 5A** and **FIG. 5B** show competitive ELISA assay graphs for 2931, 2731 and bapineuzumab (FIG. 5A) and 2726, 2831 and bapineuzumab (FIG. 5B).

[0038] **FIG. 6** shows BIAcore sensorgrams of binding of h2726 (**FIG. 6A**), h2731 (**FIG. 6B**), h2831 (**FIG. 6C**) and 2931 (**FIG. 6D**) to A β ₁₋₂₈ at analyte concentrations from 100nM to 0.39 nM (2-fold serial dilutions).

[0039] **FIG. 7** shows a BIAcore sensorgram comparing binding characteristics of humanized antibodies (PB-0569 (aducanumab), PB-0573 (h2726), PB-0574 (h2731), PB-0575 (h2831), PB-0576 (h2931)) to recombinant Abeta 1-42 (A β ₁₋₄₂) fibrils.

[0040] **FIG. 8** shows h2931 binds soluble A β oligomers with high relative affinity.

[0041] **FIG. 9** shows graphs evaluating A β fibril binding activity of 2726, 2731, 2831, 2931 versus aducanumab control. Antibody was titrated in a constant concentration of A β fibrils (left panel) or A β fibrils were titrated in a constant concentration of antibody (right panel), both indicating substantially better binding for 2726, 2731, 2831 and 2931 than for aducanumab.

[0042] **FIG. 10** shows A β binding in AD brain. Binding to tissue A β pathology appears similar among h2726, h2731, h2831 and h2931 antibodies. Examples of images stained with the four antibodies, h2726, h2731, h2831, h2931, at 0.3 μ g/ml show their pattern of staining in two AD brains with different amounts of A β pathology (AD 11-97 and AD 13-75). For each brain, the images are from the same area of the section and show comparatively similar intensity and distribution of pathology with all four antibodies. Staining with aducanumab was always the weakest (Scale bar: 500 μ m).

[0043] **FIG. 11** shows A β binding in AD brain of controls. Human IgG isotype control antibody produced no staining in AD brains. As shown in these examples, AD sections incubated with human IgG isotype at 1 μ g/ml were devoid of any staining (Scale bar: 500 μ m).

[0044] **FIG. 12** shows quantification of A β binding in AD brain. Quantification of A β pathology staining in AD tissues revealed similar binding between h2726, h2731, h2831 and h2931 antibodies. Section from four AD brains were incubated with the antibodies h2726, h2731, h2831, h2931 as well as aducanumab at the following concentrations: 0.03, 0.1, 0.3, 1, 3 and 9 μ g/ml. After imaging of sections, the percent of stained tissue area was determined morphometrically using Halo® imaging analysis software. Each graph compares measurements in an AD brain obtained with the five antibodies. The four graphs consistently

show that the binding profiles of h2726, h2731, h2831, h2931 antibodies are similar. Measurements obtained with aducanumab were significantly lower.

[0045] **FIG. 13** shows A β binding in AD brain. hBP binds to tissue A β pathology strongly and in a dose-dependent manner. Images from relatively the same area of the section (Brain AD 13-75) with similar pathology distribution. hBP shows an increase in the amount of staining with concentration, and its binding to A β pathology was stronger than that of BAN2401 or aducanumab at each concentration (Scale bar: 500 μ m).

[0046] **FIG. 14** shows individual (**FIG. 14A**) and pooled (**FIG. 14B**) results from an ex vivo phagocytosis study of h2931 and aducanumab in APP.PS1 Tg mouse tissue with primary murine microglia. h2931 and aducanumab both demonstrate highly significant reductions in A β ₁₋₄₂ over isotype control. **FIG. 14B**

[0047] **FIG. 15** shows graphs indicating a reduction of soluble oligomer binding to neurites on rat hippocampal neurons with increasing concentration of h2726, h2731, h2831 and h2931 compared to isotype control, and normalized by +/- A β addition. **FIG. 15A** shows spots per neuron and **FIG. 15B** shows total spot counts (at 40 fields per well).

[0048] **FIG. 16** shows a graph representing the percentage of A β spots per neuron with increasing concentration of 2726, 2731, 2831 and 2931 normalized by +/- A β addition.

[0049] **FIG. 17** shows an alignment of bapineuzumab variable heavy chain sequence and four sequences of the disclosure, 2726, 2731, 2831 and 2931. CDRs are in bold.

[0050] **FIG. 18** shows an alignment of bapineuzumab light chain sequence and four (variable light chain) sequences of the disclosure, 2726, 2731, 2831 and 2931. CDRs are in bold.

[0051] **FIG. 19** shows a CDR table listing the variable heavy and light chain CDR sequences for antibodies of the disclosure. **FIG. 19A** refers to heavy chain CDRs and **FIG. 19B** refers to light chain CDRs.

[0052] **FIG. 20** shows graphs measuring antibody potency for binding heterogenous aggregated A β ₄₂ species by competition ELISA. **FIG. 20A** shows h2931, h2731 and bapineuzumab control, and **FIG. 20BA** shows h2831, h2726 and bapineuzumab control.

[0053] **FIG. 21** shows graphs measuring direct binding and relative affinity of antibodies to fibrillar A β 42 by ELISA.

[0054] **FIG. 22** shows graphs measuring antibody dose response of A β plaque area binding measured as percent positive tissue by immunohistochemical staining in AD brain.

[0055] **FIG. 23** shows quantification of binding of soluble A β to rat hippocampal neurons in the presence of antibody.

[0056] **FIG. 24** shows results from an *ex vivo* phagocytosis study of h2731 in AD tissue with primary murine microglia. h2731 demonstrated highly significant reduction in A β ₁₋₄₂ indicating the antibody robustly promoted phagocytosis and removal of these species.

[0057] **FIGS. 25A and 25B** confirm the presence of pyroglutamate-3 A β (A β _{pE3-42}) in AD tissue used for *ex vivo* phagocytosis assays (Fig. 23A) and demonstrates a similar binding pattern for pyroglutamate-3 A β and h2931 (Figs 23A and B).

[0058] **FIGS. 26A and 26B** show results from an *ex vivo* phagocytosis study of h2931 and h2731 in AD tissue with primary murine microglia. h2931 and h2731 both demonstrate highly significant reductions in pyroglutamate-3 A β (A β _{pE3-42}), indicating that both antibodies robustly promote phagocytosis and removal of these species.

[0059] **FIG. 27** shows that h2731 binds the N-terminus of A β ₁₋₄₂ but not A β _{pE3-42}.

[0060] **FIGS. 28A and 28B** show that antibodies of the present invention induce phagocytosis of A β ₁₋₄₂ protofibrils in THP-1 human monocytes in vitro.

[0061] **FIG. 29A and FIG. 29B** show the distribution pattern of A β _{1-XX}, as measured by an N-terminal anti-A β antibody, compared to A β _{pE3-42} in human AD brain tissue. **FIG. 29C** shows the quantification of the percent area covered by A β _{1-XX} compared to A β _{pE3-42} in human AD brain tissue.

[0062] **FIG. 30** shows localization of h2731 to A β plaques, localization of anti-A β _{pE3-42} antibody signal to A β plaques, and colocalization of h2731 and anti-A β _{pE3-42} antibody signal to A β plaques.

[0063] **FIGS. 31A and FIG. 31B** show that anti-A β antibody h2731 promotes A β _{pE3-42} clearance from AD brain tissue *ex vivo* in a dose-dependent manner with higher potency than aducanumab.

[0064] **FIG. 32A** shows the concentration dependence of h2731 and aducanumab clearance of A β _{pE3-42} from AD brain tissue, and **FIG. 32B** shows that the effect of h2731 is microglia-dependent.

[0065] **FIG. 33** compares predicted CNS exposure of h2731 and aducanumab with repeated dosing.

[0066] **FIG. 34** shows that anti-A β antibody h2731 promotes clearance of plaques containing A β _{pE3-42} in AD brain tissue *ex vivo*.

DETAILED DESCRIPTION OF THE INVENTION

[0067] Monoclonal antibodies (mAbs) targeting the N-terminus of amyloid beta (A β) have been demonstrated clinically to reduce amyloid plaque burden and one such antibody, aducanumab, showed that significant reduction in plaque burden was associated with slowing of cognitive decline in Alzheimer's disease (AD). Preclinical studies have also indicated that monoclonal antibodies (mAbs) targeting N-terminal epitopes of A β elicit an antibody-dependent microglial-mediated A β -plaque clearance and neutralization of soluble toxic A β oligomers both *in vitro* and *in vivo*. It is hypothesized that administration of N-terminal A β targeting mAbs slows disease progression via clearance of A β plaques and neutralization of soluble A β aggregates in patients with AD.

[0068] A β antibody bapineuzumab (hBP) is a humanized antibody developed from parental murine antibody 3D6. In accordance with various aspects of the disclosure, a multipronged approach was applied to construct superior antibodies to hBP. Humanness of hBP was analyzed and a determination was made that light chain humanization could be optimized.

[0069] A search was made over the protein sequences in the PDB database [Deshpande et al, 2005] to find structures that would provide a rough structural model of hBP. The crystal structure of hBP fab PDB code 4HIX [Miles, et al., 2013] was utilized for both Vh and Vk structure as it had acceptable resolution and an exact sequence match to hBP Vh and Vk, retaining the same canonical structures for the loops.

[0070] IMGT/DomainGapAlignment was performed for the hBP VL as input sequences. to identify human germ line VK gene sequence IGHV2-30*02 as the closest matched to hBP VL. The frameworks of hBP VL share a high degree of sequence similarity with the corresponding framework regions of IGHV2-30*02. Thus, the framework regions of IGHV2-30*02 VL were chosen as the guidance sequence for further optimization of the hBP framework regions. Additional residues in CDR-L2 that do not make any direct contact with the antigen as per hBP 3D structure were also changed to germline sequence resulting in following changes.

[0071] Three different versions of VL were designed by incorporating human germline framework residues into hBP VL sequence. Canonical or interface residues were not changed. Also, based on structural observation that P15 is located at a turn and the germline gene has Leu at this position, P15L was tested in one version of the variable light chain.

[0072] Based on the 3D structural observations, substitutions at a number of residues in the light chain and heavy chain CDRs and framework were designed. Mutant VL and VH versions were generated and tested for binding in the first round of rational design. Mutations that showed improved binding were combined in the second round of the rational design. Additionally, new mutations guided by further analysis of the structure were also incorporated into the design.

[0073] Accordingly, the disclosure provides antibodies (and antibody fragments), nucleic acids encoding and methods of producing such antibodies and antibody fragments, pharmaceutical compositions, and methods for preventing or treating amyloidogenic disease, reducing the risk or delaying the outset of an amyloidogenic disease, effecting improvement of cognition in a subject having a condition related to amyloidogenic disease, inhibiting the formation of A β plaque in a subject, reducing A β plaque in the brain of a subject, inhibiting or reducing amyloid plaque in a subject at risk of developing an amyloidogenic disease, detecting amyloid plaques, measuring efficacy of a treatment in a subject being treated for an amyloidogenic disease, where amyloidogenic disease comprises Alzheimer's and others as described herein. The disclosure is based, at least in part, on the characterization of a genus of monoclonal antibodies effective at binding beta amyloid protein (A β) (*e.g.*, binding soluble and/or aggregated A β), mediating phagocytosis (*e.g.*, of aggregated A β), reducing plaque burden and/or reducing neuritic dystrophy (*e.g.*, in patient), neutralizing soluble, toxic A β species. The antibodies and fragments of the disclosure exhibit greater binding strength

(affinity and/or avidity) for pathologic fibrillar A β than reported current experimental therapies, and high affinity for soluble toxic A β forms. These antibodies may enable more convenient dosing strategies and enhanced patient access.

[0074] Before describing particular aspects of the disclosure in more detail, a number of terms are defined.

[0075] Definitions

[0076] The term “antibody” includes intact antibodies and binding fragments thereof. Typically, fragments compete with the intact antibody from which they were derived for specific binding to the target. Fragments include separate heavy chains, light chains Fab, Fab', F(ab')₂, F(ab)c, Fv and single domain antibodies. Single (variable) domain antibodies include VH regions separated from their VL partners (or vice versa) in conventional antibodies (Ward et al., 1989, Nature 341: 544-546) as well as VH regions (sometimes known as VHH) from species such as Camelidae or cartilaginous fish (e.g., a nurse shark) in which VH regions are not associated with VL regions (see, e.g., WO 9404678). Single domain antibodies in which one chain is separated from its natural partners are sometimes known as Dabs and single domain antibodies from Camelidae or cartilaginous fish are sometimes known as nanobodies. Constant regions or parts of constant regions may or may not be present in single domain antibodies. For example, natural single variable region antibodies from Camelidae include a VHH variable region, and CH2 and CH3 constant regions. Single domain antibodies can be subject of humanization by analogous approaches to conventional antibodies. The Dabs type of antibodies are usually obtained from antibodies of human origin. NANOBODY types of antibody are of Camelidae or shark origin and can be subject to humanization. Fragments can be produced by recombinant DNA techniques, or by enzymatic or chemical separation of intact immunoglobulins. The term “antibody” also includes a bispecific antibody. A bispecific or bifunctional antibody is an artificial hybrid antibody having two different heavy/light chain pairs and two different binding sites (see, e.g., Songsivilai and Lachmann, Clin. Exp. Immunol., 79:315-321 (1990); Kostelny et al., J. Immunol., 148:1547-53 (1992)).

[0077] An immunoglobulin light or heavy chain variable region (also sometimes referred to herein as a “light chain variable domain” (“VL domain”) or “heavy chain variable domain” (“VH domain”), respectively) consists of a “framework” region interrupted by three

“complementarity determining regions” or “CDRs.” The framework regions serve to align the CDRs for specific binding to an epitope of an antigen. The CDRs include the amino acid residues of an antibody that are primarily responsible for antigen binding. From amino-terminus to carboxyl-terminus, both VL and VH domains comprise the following framework (FR) and CDR regions: FR1, CDR1, FR2, CDR2, FR3, CDR3, and FR4. CDRs 1, 2, and 3 of a VL domain are also sometimes referred to herein, respectively, as CDR-L1, CDR-L2, and CDR-L3; CDRs 1, 2, and 3 of a VH domain are also sometimes referred to herein, respectively, as CDR-H1, CDR-H2, and CDR-H3. When the application discloses a VL sequence with R as the C-terminal residue, the R can alternatively be considered as being the N-terminal residue of the light chain constant region. Thus, the application should also be understood as disclosing the VL sequence without the C-terminal R.

[0078] The assignment of amino acids to each VL and VH domain is in accordance with any conventional definition of CDRs. Conventional definitions include, the Kabat definition (Kabat, Sequences of Proteins of Immunological Interest (National Institutes of Health, Bethesda, MD, 1987 and 1991), the Chothia definition (Chothia & Lesk, J. Mol. Biol. 196:901-917, 1987; Chothia et al., Nature 342:878-883, 1989); a composite of Chothia Kabat CDR in which CDR-H1 is a composite of Chothia and Kabat CDRs; the AbM definition used by Oxford Molecular’s antibody modelling software; and, the contact definition of Martin et al (bioinfo.org.uk/abs) (see Table A). Kabat provides a widely used numbering convention (Kabat numbering) in which corresponding residues between different heavy chains or between different light chains are assigned the same number. When an antibody is said to comprise CDRs by a certain definition of CDRs (e.g., Kabat) that definition specifies the minimum number of CDR residues present in the antibody (i.e., the Kabat CDRs). It does not exclude that other residues falling within another conventional CDR definition but outside the specified definition are also present. For example, an antibody comprising CDRs defined by Kabat includes among other possibilities, an antibody in which the CDRs contain Kabat CDR residues and no other CDR residues, and an antibody in which CDR H1 is a composite Chothia-Kabat CDR H1 and other CDRs contain Kabat CDR residues and no additional CDR residues based on other definitions.

Table A

Conventional Definitions of CDRs Using Kabat Numbering

Loop	Kabat	Chothia	Composite of Chothia & Kabat	AbM	Contact
L1	L24--L34	L24--L34	L24--L34	L24--L34	L30--L36
L2	L50--L56	L50--L56	L50--L56	L50--L56	L46--L55
L3	L89--L97	L89--L97	L89--L97	L89--L97	L89--L96
H1	H31--H35B	H26-- H32..H34*	H26--H35B*	H26--H35B	H30--H35B
H2	H50--H65	H52--H56	H50--H65	H50--H58	H47--H58
H3	H95--H102	H95--H102	H95--H102	H95--H102	H93--H101

*CDR-H1 by Chothia can end at H32, H33, or H34 (depending on the length of the loop). This is because the Kabat numbering scheme places insertions of extra residues at 35A and 35B, whereas Chothia numbering places them at 31A and 31B. If neither H35A nor H35B (Kabat numbering) is present, the Chothia CDR-H1 loop ends at H32. If only H35A is present, it ends at H33. If both H35A and H35B are present, it ends at H34.

[0079] In some embodiments, the CDRs of the humanized antibodies of the present invention are of a definition selected from the group of Kabat, Chothia, Kabat/Chothia Composite, AbM and Contact.

[0080] One or several amino acids at the amino or carboxy terminus of the light and/or heavy chain, such as a C-terminal lysine of the heavy chain, may be missing or derivatized in a proportion or all of the molecules. Substitutions can be made in the constant regions to reduce or increase effector function such as complement-mediated cytotoxicity or ADCC (see, e.g., Winter et al., US Patent No. 5,624,821; Tso et al., US Patent No. 5,834,597; and Lazar et al., Proc. Natl. Acad. Sci. USA 103:4005, 2006), or to prolong half-life in humans (see, e.g., Hinton et al., J. Biol. Chem. 279:6213, 2004). Exemplary substitutions include a Gln at position 250 and/or a Leu at position 428 (EU numbering is used in this paragraph for the constant region) for increasing the half-life of an antibody. Substitution at any or all of positions 234, 235, 236 and/or 237 reduce affinity for Fcγ receptors, particularly FcγRI receptor (see, e.g., US 6,624,821). An alanine substitution at positions 234, 235, and 237 of

human IgG1 can be used for reducing effector functions. Some antibodies have alanine substitution at positions 234, 235 and 237 of human IgG1 for reducing effector functions. Optionally, positions 234, 236 and/or 237 in human IgG2 are substituted with alanine and position 235 with glutamine (see, e.g., US 5,624,821). In some antibodies, a mutation at one or more of positions 241, 264, 265, 270, 296, 297, 322, 329, and 331 by EU numbering of human IgG1 is used. In some antibodies, a mutation at one or more of positions 318, 320, and 322 by EU numbering of human IgG1 is used. In some antibodies, positions 234 and/or 235 are substituted with alanine and/or position 329 is substituted with glycine. In some antibodies, positions 234 and 235 are substituted with alanine. In some antibodies, the isotype is human IgG2 or IgG4.

[0081] The term "humanized immunoglobulin" or "humanized antibody" refers to an immunoglobulin or antibody that includes at least one humanized immunoglobulin or antibody chain (i.e., at least one humanized light or heavy chain). The term "humanized immunoglobulin chain" or "humanized antibody chain" (i.e., a "humanized immunoglobulin light chain" or "humanized immunoglobulin heavy chain") refers to an immunoglobulin or antibody chain (i.e., a light or heavy chain, respectively) having a variable region that includes a variable framework region substantially from a human immunoglobulin or antibody and complementarity determining regions (CDRs) (e.g., at least one CDR, preferably two CDRs, more preferably three CDRs) substantially from a non-human immunoglobulin or antibody, and further includes constant regions (e.g., at least one constant region or portion thereof, in the case of a light chain, and preferably three constant regions in the case of a heavy chain). The term "humanized variable region" (e.g., "humanized light chain variable region" or "humanized heavy chain variable region") refers to a variable region that includes a variable framework region substantially from a human immunoglobulin or antibody and complementarity determining regions (CDRs) substantially from a non-human immunoglobulin or antibody.

[0082] Accordingly, regions or residues of a humanized immunoglobulin or antibody, or of a humanized immunoglobulin or antibody chain, except possibly the CDRs, are substantially identical to the corresponding regions or residues of one or more native human immunoglobulin sequences. The term "corresponding region" or "corresponding residue" refers to a region or residue on a second amino acid or nucleotide sequence which occupies the same (i.e., equivalent) position as a region or residue on a first amino acid or nucleotide

sequence, when the first and second sequences are optimally aligned for comparison purposes.

[0083] The term “epitope” or “antigenic determinant” refers to a site on an antigen to which an antibody binds. An epitope can be formed from contiguous amino acids or noncontiguous amino acids juxtaposed by tertiary folding of one or more proteins. Epitopes formed from contiguous amino acids are typically retained on exposure to denaturing solvents whereas epitopes formed by tertiary folding are typically lost on treatment with denaturing solvents. An epitope typically includes at least 3, and more usually, at least 5 or 8-10 amino acids in a unique spatial conformation. When an epitope is said to be within a range of amino acid residues in a protein (e.g., within residues 1 to 6 of A β), the range is inclusive of the residues defining its borders. Certain residues within the range contribute to the epitope, whereas others may not. The residues that form the epitope may or may not be contiguous with one another. Similarly, when an antibody binds to an epitope found within a particular range of amino acids, the antibody need not contact all the amino acids residues within the range, and the residues of the epitope that are contacted by the antibody may or may not be contiguous with one another. Methods of determining spatial conformation of epitopes include, for example, x-ray crystallography and 2-dimensional nuclear magnetic resonance. See, e.g., Epitope Mapping Protocols, in *Methods in Molecular Biology*, Vol. 66, Glenn E. Morris, Ed. (1996).

[0084] Antibodies that recognize the same epitope can be identified in a simple immunoassay showing the ability of one antibody to block or compete with the binding of another antibody to a target antigen, i.e., a competitive binding assay. Competitive binding is determined in an assay in which the immunoglobulin under test inhibits specific binding of a reference antibody to a common antigen, such as A β . Numerous types of competitive binding assays are known, for example: solid phase direct or indirect radioimmunoassay (RIA), solid phase direct or indirect enzyme immunoassay (EIA), sandwich competition assay (see Stahl et al., *Methods in Enzymology* 9:242 (1983)); solid phase direct biotin-avidin EIA (see Kirkland et al., *J. Immunol.* 137:3614 (1986)); solid phase direct labeled assay, solid phase direct labeled sandwich assay (see Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Press (1988)); solid phase direct label RIA using I-125 label (see Morel et al., *Mol. Immunol.* 25(1):7 (1988)); solid phase direct biotin-avidin EIA (Cheung et al., *Virology* 176:546 (1990)); and direct labeled RIA. (Moldenhauer et al., *Scand. J. Immunol.* 32:77

(1990)). Typically, such an assay involves the use of purified antigen bound to a solid surface or cells bearing either of these, an unlabeled test immunoglobulin and a labeled reference immunoglobulin. Competitive inhibition is measured by determining the amount of label bound to the solid surface or cells in the presence of the test immunoglobulin. Usually the test immunoglobulin is present in excess. Usually, when a competing antibody is present in excess, it will inhibit specific binding of a reference antibody to a common antigen by at least 50-55%, 55-60%, 60-65%, 65-70%, 70-75%, or more.

[0085] Competition between antibodies is determined by an assay in which an antibody under test inhibits specific binding of a reference antibody (e.g. 3D6, aducanumab, bapineuzumab) to a common antigen (see, e.g., Junghans et al., *Cancer Res.* 50:1495, 1990). A test antibody competes with a reference antibody if an excess of a test antibody (e.g., at least 2×, 5×, 10×, 20× or 100×) inhibits binding of the reference antibody by at least 50% but preferably 75%, 90% or 99% as measured in a competitive binding assay. Antibodies identified by competition assay (competing antibodies) include antibodies binding to the same epitope as the reference antibody and antibodies binding to an adjacent epitope sufficiently proximal to the epitope bound by the reference antibody for steric hindrance to occur.

[0086] The epitope of an antibody can also be defined by X-ray crystallography of the antibody bound to its antigen to identify contact residues. Alternatively, two antibodies have the same epitope if all amino acid mutations in the antigen that reduce or eliminate binding of one antibody reduce or eliminate binding of the other. Two antibodies have overlapping epitopes if some amino acid mutations that reduce or eliminate binding of one antibody reduce or eliminate binding of the other.

[0087] An epitope is also recognized by immunologic cells, for example, B cells and/or T cells. Cellular recognition of an epitope can be determined by in vitro assays that measure antigen-dependent proliferation, as determined by ³H-thymidine incorporation, by cytokine secretion, by antibody secretion, or by antigen-dependent killing (cytotoxic T lymphocyte assay).

[0088] Exemplary epitopes or antigenic determinants can be found within the human amyloid precursor protein (APP) but are preferably found within the Aβ peptide of APP. Multiple isoforms of APP exist, for example APP⁶⁹⁵, APP⁷⁵¹, and APP⁷⁷⁰. Amino acids

within APP are assigned numbers according to the sequence of the APP⁷⁷⁰ isoform (see e.g., GenBank Accession No. P05067, also set forth as SEQ ID NO:85).

[0089] A β (also referred to herein as beta amyloid peptide and A-beta) peptide is a about 4-kDa internal fragment of 39-43 amino acids of APP (A β 39, A β 40, A β 41, A β 42, and A β 43). A β 40, for example, consists of residues 672-711 of APP and A β 42 consists of residues 673-713 of APP. As a result of proteolytic processing of APP by different secretase enzymes *in vivo* or *in situ*, A β is found in both a "short form", 40 amino acids in length, and a "long form", ranging from 42-43 amino acids in length. Preferred epitopes or antigenic determinants, as described herein, are located within the N-terminus of the A β peptide and include residues within amino acids 1-10 of A β , preferably from residues 1-3, 1-4, 1-5, 1-6, 1-7, or 3-7 of A β 42. Additional referred epitopes or antigenic determinants include residues 2-4, 5, 6, 7, or 8 of A β , residues 3-5, 6, 7, 8, or 9 of A β , or residues 4-7, 8, 9, or 10 of A β 42.

[0090] "Soluble" or "dissociated" A β refers to A β species that are either monomeric, aggregated, oligomeric, associated or not with other proteins and lipids, which remain in solution (supernatant) after centrifugation at 100,000 $\times$ g. "Insoluble" A β refers to aggregated A β species, amyloid (beta-sheet) or not, that do not remain in solution after 100,000 $\times$ g centrifugation, for example, A β held together by noncovalent bonds. A β (e.g., A β 42) is believed to aggregate, at least in part, due to the presence of hydrophobic residues at the C-terminus of the peptide (part of the transmembrane domain of APP). One method to prepare soluble A β is to dissolve lyophilized peptide in neat DMSO with sonication. The resulting solution is centrifuged to remove any insoluble particulates.

[0091] "Specific binding" of an antibody mean that the antibody exhibits appreciable affinity for antigen or a preferred epitope and, preferably, does not exhibit significant cross reactivity. "Appreciable" or preferred binding include binding with an affinity of at least 10^6 , 10^7 , 10^8 , 10^9 M⁻¹, or 10^{10} M⁻¹. Affinities greater 10^7 M⁻¹, preferably greater than 10^8 M⁻¹ are more preferred. Values intermediate of those set forth herein are also intended to be within the scope of the present disclosure and a preferred binding affinity can be indicated as a range of affinities, for example, 10^6 to 10^{10} M⁻¹, preferably 10^7 to 10^{10} M⁻¹, more preferably 10^8 to 10^{10} M⁻¹. An antibody that "does not exhibit significant cross reactivity" is one that will not appreciably bind to an undesirable entity (e.g., an undesirable proteinaceous entity). For example, an antibody that specifically binds to A β will appreciably bind A β but will not significantly react with non-A β proteins or peptides (e.g., non-A β proteins or peptides).

included in plaques). An antibody specific for a preferred epitope will, for example, not significantly cross-react with remote epitopes on the same protein or peptide. Specific binding can be determined according to any art-recognized means for determining such binding. Preferably, specific binding is determined according to Scatchard analysis and/or competitive binding assays.

[0092] Binding fragments are produced by recombinant DNA techniques, or by enzymatic or chemical cleavage of intact immunoglobulins. Binding fragments include Fab, Fab', F(ab')₂, Fabc, Fv, single chains, and single-chain antibodies.

[0093] The term "patient" includes human and other mammalian subjects that receive either prophylactic or therapeutic treatment.

[0094] The term "effective dose" or "effective dosage" is defined as an amount sufficient to achieve or at least partially achieve the desired effect. The term "therapeutically effective dose" is defined as an amount sufficient to cure or at least partially arrest the disease and its complications in a patient already suffering from the disease. Amounts effective for this use will depend upon the severity of the infection and the general state of the patient's own immune system.

[0095] The term "treatment" as used herein, is defined as the application or administration of a therapeutic agent to a patient, or application or administration of a therapeutic agent to an isolated tissue or cell line from a patient, who has a disease, a symptom of disease or a predisposition toward a disease, with the purpose to cure, heal, alleviate, relieve, alter, remedy, ameliorate, improve or affect the disease, the symptoms of disease or the predisposition toward disease.

[0096] The term "amyloidogenic disease" includes any disease associated with (or caused by) the formation or deposition of insoluble amyloid fibrils or amyloid plaques. Exemplary amyloidogenic diseases include, but are not limited to systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, mild cognitive impairment, prion-related transmissible spongiform encephalopathies (kuru and Creutzfeldt-Jacob disease in humans and scrapie and BSE in sheep and cattle, respectively), and the like. Different amyloidogenic diseases are defined or characterized by the nature of the polypeptide component of the fibrils deposited. For example, in subjects or patients having Alzheimer's disease, β -amyloid protein (e.g.,

wild-type, variant, or truncated β -amyloid protein) is the characterizing polypeptide component of the amyloid deposit. Accordingly, Alzheimer's disease is an example of a "disease characterized by deposits of $A\beta$ " or a "disease associated with deposits of $A\beta$ ", e.g., in the brain of a subject or patient. The terms " β -amyloid protein", " β -amyloid peptide", " β -amyloid", " $A\beta$ " and " $A\beta$ peptide" are used interchangeably herein.

[0097] An individual is at increased risk of a disease if the subject has at least one known risk-factor (e.g., genetic, biochemical, family history, situational exposure) placing individuals with that risk factor at a statistically significant greater risk of developing the disease than individuals without the risk factor.

[0098] The term "symptom" refers to a subjective evidence of a disease, such as altered gait, as perceived by the patient. A "sign" refers to objective evidence of a disease as observed by a physician.

[0099] Statistical significance means $p < 0.05$.

[00100] Anti- $A\beta$ Antibodies

[00101] Turning now to various aspects of the disclosure, a first aspect the disclosure is directed to an antibody or fragment thereof that specifically binds to $A\beta$ peptide. The antibody or fragment includes the heavy chain CDRs and the light chain CDRs from one of the constructs identified herein as h2726, h2731, h2831, h2931, h2926, h4921, h2828, h2929, h3818G, h2927, h49k3G, h4917G, h2727, and h4918G. Particular monoclonal antibodies of the disclosure may bind to an epitope within residues 1-6 of $A\beta$ (with the first N terminal residue of natural $A\beta$ designated 1). Some monoclonal antibodies bind to an epitope within amino acids 1-6, some to an epitope within 1-5, and some to an epitope within 1-4. Some antibodies bind to epitopes within amino acids 1-3, 2-5, 3-5, 2-4, 2-5, 2-6, 3-5, or 3-6. When an antibody is said to bind to an epitope within specified residues, such as $A\beta$ 1-6 for example, what is meant is that the antibody specifically binds to a polypeptide containing the specified residues (i.e., $A\beta$ 1-6 in this an example); such antibody does not necessarily contact every residue within $A\beta$ 1-6.

[00102] In another aspect, the antibody or fragment includes a heavy chain variable region having a heavy chain CDR1, CDR2 and CDR3 and a light chain variable region comprising a light chain CDR1, CDR2 and CDR3 from the constructs show in Table 1A.

Table 1A

Construct ID	VH/VL Sequences		SEQ ID	CDR Sequences		SEQ ID
h2726	VH	EVQLLESGGGLVQP GGS LRLSCAASGFTFSNYGM SWVRQAPGKGLEWVASI RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGSSDYWGQGT LVTVSS	3	1	GFTFS NYGMS	16
				2	SIRSG SGRTY YSDNV KG	20
				3	YDHYS GSSDY	18
	VL	DVVMTQSPLSLPVT PGE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTHFPRT FGQGTKVEIK	8	1	KSSQS LLDYD GKTYL N	29
				2	KVSNR DS	33
				3	WQGT H FPRT	28
h2731	VH	EVQLLESGGGLVQP GGS LRLSCAASGFTFSNYGM SWVRQAPGKGLEWVASI RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGSSDYWGQGT LVTVSS	3	1	GFTFS NYGMS	16
				2	SIRSG SGRTY YSDNV KG	20
				3	YDHYS GSSDY	18
	VL	DVVMTQSPLSLPVT <u>L</u> GE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYRV TNRDTGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTHFP RS FGQGTKVEIK	9	1	KSSQS LLDYD GKTYL N	29
				2	RVTNR DT	34
				3	WQGT H FPRS	38
h2831	VH	EVQLLESGGGLVQP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGTSDYWGQGT LVTVSS	4	1	GFTFS NFGMS	19
				2	SVRSG SGRTY YSDNV KG	21
				3	YDHYS GTSDY	24
	VL	DVVMTQSPLSLPVT <u>L</u> GE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYRV TNRDTGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTHFP RS FGQGTKVEIK	9	1	KSSQS LLDYD GKTYL N	29
				2	RVTNR DT	34
				3	WQGT H FPRS	38
h2931	VH	EVQLLESGGGLVQP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY TGTSDYWGQGT LVTVSS	5	1	GFTFS NFGMS	19
				2	SVRSG SGRTY YSDNV KG	21
				3	YDHYT GTSDY	25

	VL	DVVMTQSPLSLPVT L GE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYRVNTNRDTGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTFFPRS FGQGTKVEIK	9	1	KSSQS LLDYD GKTYL N	29
				2	RVTNR DT	34
				3	WQGTTH FPRS	38
h2926	VH	EVQLES GGGLVQPGGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY TGTSDYWGQGT LVTVSS	5	1	GFTFS NFGMS	19
				2	SVRSG SGRTY YSDNV KG	21
				3	YDHYT GTSDY	25
	VL	DVVMTQSPLSLPVT P GE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTFFPRT FGQGTKVEIK	8	1	KSSQS LLDYD GKTYL N	29
				2	KVSNR DS	33
				3	WQGTTH FPRT	28
h4921G	VH	EVQLES GGGLVQPGGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGGGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGTSDYWGQGT LVTVSS	6	1	GFTFS NFGMS	19
				2	SVRSG GGRTY YSDNV KG	22
				3	YDHYS GTSDY	24
	VL	DVVMTQSPLSLPVT L GE PASISCKSSQSLLDSG KTYLNWLLQKPGQSPQR LIYRVNTNRDTGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTFFPRT FGQGTKVEIK	10	1	KSSQS LLDSG GKTYL N	26
				2	RVTNR DT	34
				3	WQGTTH FPRT	28
h2826	VH	EVQLES GGGLVQPGGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGTSDYWGQGT LVTVSS	4	1	GFTFS NFGMS	19
				2	SVRSG SGRTY YSDNV KG	21
				3	YDHYS GTSDY	24
	VL	DVVMTQSPLSLPVT P GE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGTFFPRT FGQGTKVEIK	8	1	KSSQS LLDYD GKTYL N	29
				2	KVSNR DS	33
				3	WQGTTH FPRT	28
h2929	VH	EVQLES GGGLVQPGGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS	5	1	GFTFS NFGMS	19
				2	SVRSG SGRTY YSDNV KG	21
				3	YDHYT GTSDY	25

		LRAEDTAVYYCVRYDHY TGTSDYWQGT LVT VSS				
	VL	DVMTQSPLSLPVT PGE PASISCRSSQSLVDYDG KTYLNWLLQRPQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVIYCWQGSHPFRS YGQGTKVEIK	11	1 2 3	RSSQS LVDYD GKTYL N KVSNR DS WQGSF FPRS	31 33 39
h3818G	VH	EVQLLES GGG LVP GGS LRLSCAASGFTFANYGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGSSDYWQGT LVT VSS	7	1 2 3	GFTFA NYGMS SVRSG GSRTY YSDNV KG YDHYS GSSDY	20 23 18
	VL	DVMTQSPLSLPVT LGE PASISCKSSQSLMDTDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVIYCWQGT HFPRT FGQGTKVEIK	12	1 2 3	KSSQS LMDTD GKTYL N KVSNR ES WQGT H FPRT	32 35 28
h2927	VH	EVQLLES GGG LVP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY TGTSDYWQGT LVT VSS	5	1 2 3	GFTFS NFGMS SVRSG SGRTY YSDNV KG YDHYT GTSDY	19 21 25
	VL	DVMTQSPLSLPVT PGE PASISCKSSQSLLDYDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVIYCWQGT HFPRT FGQGTKVEIK	13	1 2 3	KSSQS LLDYD GKTYL N KVSNR DS WQGT H FPRS	29 33 38
h49k3G	VH	EVQLLES GGG LVP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF TISRDN SKNTLYLQMNS LRAEDTAVYYCVRYDHY SGTSDYWQGT LVT VSS	6	1 2 3	GFTFS NFGMS SVRSG GGRTY YSDNV KG YDHYS GTSDY	19 22 24
	VL	DVMTQSPLSLPVT LGE PASISCKSSQSLDSDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVIYCWQGT HFPRT FGQGTKVEIK	14	1 2 3	KSSQS LLDSD GKTYL N KVSNR DS WQGT H FPRT	26 33 28
h4917G	VH	EVQLLES GGG LVP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGSGRTYYSDNVKGRF	6	1 2 3	GFTFS NFGMS SVRSG GGRTY YSDNV KG YDHYS GTSDY	19 22 24

		TISRDN SKNTLY LQMNS LRAEDTAVYYCVRYDHY SGTSDYWGQGLVTVSS				
	VL	DVVMTQSPLSLPVT <u>L</u> GE PASISCKSSQSLDSDG KTYLNWLLQKPGQSPQR LIYKVTNRESGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGT HFP RS FGQGTKVEIK	15	1	KSSQS LLDSD GKTYL N	26
				2	KVTNR ES	36
				3	WQGT H FPRS	38
h2727	VH	EVQLLES GGLVQP GGS LRLSCAASGFTFSNYGM SWVRQAPGKGLEWVASI RSGSGRTYYSDNVKGRF TISRDN SKNTLY LQMNS LRAEDTAVYYCVRYDHY SGSSDYWGQGLVTVSS	3	1	GFTFS NYGMS	16
				2	SIRSG SGRTY YSDNV KG	20
				3	YDHYS GSSDY	18
	VL	DVVMTQSPLSLPVT <u>L</u> GE PASISCKSSQSLDSDG KTYLNWLLQKPGQSPQR LIYKVSNRDSGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGT HFP RS FGQGTKVEIK	13	1	KSSQS LLDYD GKTYL N	29
				2	KVSNR DS	33
				3	WQGT H FPRS	38
h4918G	VH	EVQLLES GGLVQP GGS LRLSCAASGFTFSNFGM SWVRQAPGKGLEWVASV RSGGGRTYSDNVKGRF TISRDN SKNTLY LQMNS LRAEDTAVYYCVRYDHY SGTSDYWGQGLVTVSS	6	1	GFTFS NFGMS	19
				2	SVRSG GGRTY YSDNV KG	22
				3	YDHYS GTSDY	24
	VL	DVVMTQSPLSLPVT <u>L</u> GE PASISCKSSQSLMDTDG KTYLNWLLQKPGQSPQR LIYKVSNRESGVPDRFS GSGSGTDFTLKISRVEA EDVGVYYCWQGT HFP RT FGQGTKVEIK	12	1	KSSQS LMDTD GKTYL N	32
				2	KVSNR ES	25
				3	WQGT H FPRT	28

[00103] In another aspect the antibody or fragment of the disclosure includes a heavy chain variable region (VH) as shown for one of the constructs in Table 1. The antibody or fragment may also include light chain variable region (VL) as shown for one of the constructs in Table 1A.

[00104] An alignment of the CDRs for each of the heavy chain and light chain sequences identified in Table 1A and the CDRs from bapineuzumab (“Bapi”, “hBP”) is shown in Figures 19A and 19B. In one aspect, the disclosure is directed an antibody or fragment thereof including a heavy chain CDR1, CDR2, and CDR3, wherein CDR1 may be selected from any one of SEQ ID NOS: 16, 19 and 20, wherein CDR2 may be selected from any one of SEQ ID

NOS: 17, 20, 21, 22, and 23 and wherein CDR3 may be selected from any one of SEQ ID NOS: 18, 24, 25. In addition, the antibody or fragment thereof includes a light chain CDR1, CDR2, and CDR3, wherein CDR1 may be selected from any one of SEQ ID NOS: 26, 29, 31, and 32, wherein CDR2 may be selected from any one of SEQ ID NOS: 27, 33, 34 and 35, and wherein CDR3 may be selected from any one of SEQ ID NOS: 28, 38 and 39. In each of these embodiments, the heavy chain CDRs and the light chain CDRs are not, in combination, simultaneously SEQ ID NOS: 16, 17, 18, 26, 27 and 28.

[00105] Analysis of protein modeling information for the antibodies described above identified two changes in the CDRs that, among others, were the contributors to increased avidity/affinity characteristics of the antibodies of the disclosure:

CDR-L1: S32Y (Ser to Tyr at position 32), and

CDR-H2: G55S (Gly to Ser at position 54)

[00106] Anti-A β antibodies with Tyr at position 32 in CDR-L1 and Ser at position 54 in CDR-H2 that bind the same epitope bound by antibodies listed herein are expected to have the same properties as the listed identified antibodies (*See* Table 1A and Figure 19A and Figure 19B). Antibodies disclosed that do not have Tyr at position 32 in CDR-L1 and Ser at position 55 in CDR-H2 can be modified to possess Tyr at position 32 in CDR-L1 and Ser at position 55 in CDR-H2 and can be expected to confer similar binding properties to such antibodies identified herein.

[00107] Examples of a CDR-L1 with Tyr at position 32 include SEQ NOS: 29 and 31. Examples of a CDR-H2 with Ser at position 55 include SEQ Nos: 20 and 21.

[00108] As examples, antibodies comprising a CDR-L1 with Tyr at position 32 and a CDR-H2 with Ser at position 55 include antibodies with the CDRs of h2726, h2731, h2727, h2826, h2831, h2926, h2927, h2931, h2929 (*See* Table 1A). Additional such antibodies include antibodies comprising LC CDRs 1, 2, 3 and HC CDRs 1, 2, 3 as set forth in the table below in Table 1B.

Table 1B

Antibody	HC/LC	CDR Sequences (HC 1, 2, 3; LC 1, 2, 3)		SEQ ID
h2729	HC	1	GFTFS NYGMS	16
		2	SIRSG SGRTY YSDNV KG	20

	LC	3	YDHYS GSSDY	18
		1	RSSQS LVDYD GKTYL N	31
		2	KVSNR DS	33
		3	WQGSF FPRS	39
h2829	HC	1	GFTFS NFGMS	19
		2	SVRSG SGRTY YSDNV KG	21
		3	YDHYS GTSDY	24
	LC	1	RSSQS LVDYD GKTYL N	31
		2	KVSNR DS	33
		3	WQGSF FPRS	39
h2827	HC	1	GFTFS NFGMS	19
		2	SVRSG SGRTY YSDNV KG	21
		3	YDHYS GTSDY	24
	LC	1	KSSQS LLDYD GKTYL N	29
		2	RVTNR DT	33
		3	WQGTG FPRS	38
HC-S55/ LC-Y32	HC	1	GFTFS NYGMS	16
		2	SIRSG SGRTY YSDNV KG	20
		3	YDHYS GSSDY	18
	LC	1	KSSQS LLDYD GKTYL N	29
		2	LVSCL DS	27
		3	WQGTG FPRT	28

[00109] In view of the binding properties identified for the antibodies identified herein, consensus sequences can be identified that would be expected to provide similar binding properties. For example, in embodiments of the disclosure, antibodies or binding fragments thereof that specifically bind to A β peptide may include heavy chain variable regions having heavy chain CDR1, CDR2 and CDR3 and a light chain variable regions having light chain CDR1, CDR2 and CDR3, as follows:

heavy chain CDR1 comprises amino acid sequence GFTFSNX₁GMS, wherein X₁ is Y or F (SEQ ID NO: 88);

heavy chain CDR2 comprises amino acid sequence SX₁RSGSGRTYYSDNVKG, wherein X₁ is I or V (SEQ ID NO: 89);

heavy chain CDR3 comprises amino acid sequence YDHYX₁GX₂SDY, wherein X₁ is S or T and X₂ is S or T (SEQ ID NO: 90);

light chain CDR1 comprises amino acid sequence KSSQSLLDYDGKTYLN (SEQ ID NO: 91);

light chain CDR2 comprises amino acid sequence $X_1VX_2NRDX_3$, wherein X_1 is K or R, X_2 is S or T, and X_3 is S or T (SEQ ID NO: 92).

light chain CDR3 comprises amino acid sequence WQGTHFPRX₁, wherein X_1 is S or T (SEQ ID NO: 93).

[00110] In some embodiments, the light chain CDR3 comprises WQGTHFPRX₁FX₂, wherein X_1 is S or T and X_2 is F or Y (SEQ ID NO: 94).

[00111] Similar consensus sequences that may be expected to provide binding properties similar to the antibodies described herein include a heavy chain variable region having heavy chain CDR1, CDR2 and CDR3 and a light chain variable region having light chain CDR1, CDR2 and CDR3, as follows:

heavy chain CDR1 comprises amino acid sequence GFTFX₁NX₂GMS, wherein X_1 is S or A, and X_2 is Y or F (SEQ ID NO: 95);

heavy chain CDR2 comprises amino acid sequence SX₁RSGX₂X₃RTYYSDNVKG, wherein X_1 is I or V, X_2 is S or G and X_3 is S or G (SEQ ID NO: 96);

heavy chain CDR3 comprises amino acid sequence YDHYX₁GX₂SDY, wherein X_1 is S or T and X_2 is S or T (SEQ ID NO: 90);

light chain CDR1 comprises amino acid sequence X₁SSQSLX₂DX₃DGKTYLN, wherein X_1 is K or R, X_2 is V, M or L, and X_3 is Y, T or S (SEQ ID NO: 97);

light chain CDR2 comprises amino acid sequence $X_1VX_2NRX_3X_4$, wherein X_1 is K or R, X_2 is S or T, and X_3 is E or D, and X_4 is S or T (SEQ ID NO: 98).

light chain CDR3 comprises amino acid sequence WQGX₁HFPRX₂, wherein X_1 is S or T, and X_2 is S or T (SEQ ID NO: 99).

[00112] In some embodiments, the light chain CDR3 comprises WQGTHFPRX₁FX₂X₃, wherein X_1 is S or T, X_2 is S or T and X_3 is F or Y (SEQ ID NO: 100).

[00113] In addition, the light and heavy variable regions may be at least at least 75% identical to the light and heavy chain variable regions show in Table 1A. For example, the light and heavy chain variable regions may be 75% identical, 80% identical, 85% identical, 90% identical, 95% identical, 96% identical, 97% identical, 98% identical, 99% identical, of 100% identical to VH and/or VL sequences identified in Table 1A. In various aspects, any

sequence variation in the VH and VL may be present outside the CDRs so that the VH and VL sequences of the disclosure include the CDRs identified in Table 1A, but the regions of the VH and VL sequences outside of the CDRs may be at least 75% identical to the regions outside the CDRs of the VH and VL sequences in Table 1A.

[00114] For example, the antibody or fragment of the disclosure may include a heavy chain variable region, excluding the CDRs, that is at least 95% identical to one of SEQ ID NOS: 3, 4, 5, 6 and 7, and the light chain variable region, excluding the CDRs, that is at least 95% identical to one of SEQ ID NOS: 8, 9, 10, 11, 12, 13, 14 and 15.

[00115] The antibodies and fragments of the disclosure may also include a heavy chain constant region that is at least 75% identical to SEQ ID NO: 40. For example, the heavy chain constant region may be 75% identical, 80%, identical, 85% identical, 90% identical, 95% identical, 96% identical, 97% identical, 98% identical, 99% identical, of 100% identical to SEQ ID NO: 40.

[00116] The antibodies and fragments of the disclosure may also include a light chain constant region that is at least 75% identical to SEQ ID NO: 41. For example, the heavy chain constant region may be 75% identical, 80%, identical, 85% identical, 90% identical, 95% identical, 96% identical, 97% identical, 98% identical, 99% identical, of 100% identical to SEQ ID NO: 41.

[00117] A variant antibodies or fragments that are less than 100% identical to the sequences described in Table 1A (plus any constant region) can differ from an anti-A β antibody of Table 1A by as few as 1 to 15 amino acid residues, as few as 1 to 10 amino acid residues, such as 6-10, as few as 5, as few as 4, 3, 2, or even 1 amino acid residue. A “conservative amino acid substitution” is one in which the amino acid residue is replaced with an amino acid residue having a side chain with a similar charge. Families of amino acid residues having side chains with similar charges have been defined in the art. These families include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine). Alternatively, mutations can be introduced randomly

along all or part of the coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for biological activity to identify mutants that retain activity (e.g., the ability to bind an A β polypeptide).

[00118] For example, it is possible to introduce mutations only in framework regions of the antibody molecules. Introduced mutations can be silent or neutral missense mutations, i.e., have no, or little, effect on an antibody's ability to bind antigen. These types of mutations can be useful to optimize codon usage, or improve a hybridoma's antibody production. Alternatively, non-neutral missense mutations can alter an antibody's ability to bind antigen. One of skill in the art would be able to design and test mutant molecules with desired properties such as no alteration in antigen binding activity or alteration in binding activity (e.g., improvements in antigen binding activity or change in antibody specificity). Following mutagenesis, the encoded protein can routinely be expressed and the functional and/or biological activity of the encoded protein, (e.g., ability to immunospecifically bind at least one epitope of an A β polypeptide) can be determined using techniques described herein or by routinely modifying techniques known in the art.

[00119] In each of the foregoing embodiments, the antibody or fragment of the disclosure may be a humanized antibody as described herein. For example, the antibody may be a human IgG1 antibody. In addition, the antibody may be a full antibody, a chimeric antibody, a CDR-grafted antibody, or a recombinant antibody. Fragments of the antibody may be a Fab, Fab', F(ab')₂, Fabc, or Fv. Fragments are produced by recombinant DNA techniques, or by enzymatic or chemical separation of intact immunoglobulins.

[00120] The antibody or binding fragments, variant, or derivative disclosed herein can be said to bind to A β or a fragment or variant thereof with an off rate ($k(\text{off})$) of less than or equal to $5 \times 10^{-2} \text{ sec}^{-1}$, 10^{-2} sec^{-1} , $5 \times 10^{-3} \text{ sec}^{-1}$ or 10^{-3} sec^{-1} . In certain embodiments, an antibody of the disclosure can be said to bind A β or a fragment or variant thereof with an off rate ($k(\text{off})$) less than or equal to $5 \times 10^4 \text{ sec}^{-1}$, 10^{-4} sec^{-1} , $5 \times 10^{-5} \text{ sec}^{-1}$, or 10^{-5} sec^{-1} , $5 \times 10^{-6} \text{ sec}^{-1}$, 10^{-6} sec^{-1} , $5 \times 10^{-7} \text{ sec}^{-1}$ or 10^{-7} sec^{-1} .

[00121] An antibody or antigen-binding fragment, variant, or derivative disclosed herein can be said to bind a target polypeptide disclosed herein (e.g., A β) or a fragment or variant thereof with an on rate ($k(\text{on})$) of greater than or equal to $10^3 \text{ M}^{-1} \text{ sec}^{-1}$, $5 \times 10^3 \text{ M}^{-1} \text{ sec}^{-1}$, $10^4 \text{ M}^{-1} \text{ sec}^{-1}$ or $5 \times 10^4 \text{ M}^{-1} \text{ sec}^{-1}$. In certain embodiments, an antibody of the disclosure

can be said to bind a target polypeptide disclosed herein (e.g., A β) or a fragment or variant thereof with an on rate (k(on)) greater than or equal to $10^5 \text{ M}^{-1} \text{ sec}^{-1}$, $5 \times 10^5 \text{ M}^{-1} \text{ sec}^{-1}$, $10^6 \text{ M}^{-1} \text{ sec}^{-1}$, or $5 \times 10^6 \text{ M}^{-1} \text{ sec}^{-1}$ or $10^7 \text{ M}^{-1} \text{ sec}^{-1}$.

[00122] Anti-A β antibodies or antigen-binding fragments, variants or derivatives thereof, as described herein can also be described or specified in terms of their binding affinity A β . Binding affinities can include those with a dissociation constant or Kd less than $5 \times 10^{-2} \text{ M}$, 10^{-2} M , $5 \times 10^{-3} \text{ M}$, 10^{-3} M , $5 \times 10^{-4} \text{ M}$, 10^{-4} M , $5 \times 10^{-5} \text{ M}$, 10^{-5} M , $5 \times 10^{-6} \text{ M}$, 10^{-6} M , $5 \times 10^{-7} \text{ M}$, 10^{-7} M , $5 \times 10^{-8} \text{ M}$, 10^{-8} M , $5 \times 10^{-9} \text{ M}$, 10^{-9} M , $5 \times 10^{-10} \text{ M}$, 10^{-10} M , $5 \times 10^{-11} \text{ M}$, 10^{-11} M , $5 \times 10^{-12} \text{ M}$, 10^{-12} M , $5 \times 10^{-13} \text{ M}$, 10^{-13} M , $5 \times 10^{-14} \text{ M}$, 10^{-14} M , $5 \times 10^{-15} \text{ M}$, or 10^{-15} M .

[00123] Expression of Recombinant Antibodies

[00124] The disclosure is also directed to recombinant polynucleotides encoding antibodies which, when expressed, include the heavy and light chain CDRs of the antibodies of the disclosure. Exemplary polynucleotides, which on expression code for the polypeptide chains comprising the heavy and light chain CDRs of monoclonal antibodies are provided herein (e.g., SEQ ID NO: 42 through SEQ ID NO: 69), which code for the variable light and heavy chain polypeptides, and CDRs thereof, according to SEQ ID NO: 1 through SEQ ID NO: 39. Due to codon degeneracy, other polynucleotide sequences can be readily substituted for those sequences.

[00125] Humanized and human antibodies are typically produced by recombinant expression. Nucleic acids encoding humanized light and heavy chain variable regions may be linked to constant regions are inserted into expression vectors. The light and heavy chains can be cloned in the same or different expression vectors. The DNA segments encoding immunoglobulin chains are operably linked to control sequences in the expression vector(s) that ensure the expression of immunoglobulin polypeptides. Expression control sequences include, but are not limited to, promoters (e.g., naturally-associated or heterologous promoters), signal sequences, enhancer elements, and transcription termination sequences. Preferably, the expression control sequences are eukaryotic promoter systems in vectors capable of transforming or transfecting eukaryotic host cells. Once the vector has been incorporated into the appropriate host, the host is maintained under conditions suitable for high level expression of the nucleotide sequences, and the collection and purification of the cross-reacting antibodies.

[00126] These expression vectors are typically replicable in the host organisms either as episomes or as an integral part of the host chromosomal DNA. Commonly, expression vectors contain selection markers (e.g., ampicillin-resistance, hygromycin-resistance, tetracycline resistance or neomycin resistance) to permit detection of those cells transformed with the desired DNA sequences.

[00127] One prokaryotic host useful for cloning the polynucleotides of the present disclosure is *E. coli*. Other microbial hosts suitable for use include bacilli, such as *Bacillus subtilis*, and other enterobacteriaceae, such as *Salmonella*, *Serratia*, and various *Pseudomonas* species. In these prokaryotic hosts, one can also make expression vectors, which will typically contain expression control sequences compatible with the host cell (e.g., an origin of replication). In addition, any number of a variety of well-known promoters will be present, such as the lactose promoter system, a tryptophan (trp) promoter system, a beta-lactamase promoter system, or a promoter system from phage lambda. The promoters will typically control expression, optionally with an operator sequence, and have ribosome binding site sequences and the like, for initiating and completing transcription and translation.

[00128] Other microbes, such as yeast, are also useful for expression. *Saccharomyces* is a preferred yeast host, with suitable vectors having expression control sequences (e.g., promoters), an origin of replication, termination sequences and the like as desired. Typical promoters include 3-phosphoglycerate kinase and other glycolytic enzymes. Inducible yeast promoters include, among others, promoters from alcohol dehydrogenase, isocytochrome C, and enzymes responsible for maltose and galactose utilization. Additionally, plants (e.g., rice, tobacco) are useful for expression.

[00129] Mammalian tissue cell culture may also be used to express and produce the polypeptides of the present disclosure (e.g., polynucleotides encoding immunoglobulins or fragments thereof). Eukaryotic cells can be particularly useful because a number of suitable host cell lines capable of secreting heterologous proteins (e.g., intact immunoglobulins) have been developed in the art, and include CHO cell lines, various Cos cell lines, HeLa cells, preferably, myeloma cell lines, or transformed B-cells or hybridomas. Preferably, the cells are nonhuman. Expression vectors for these cells can include expression control sequences, such as an origin of replication, a promoter, and an enhancer, and necessary processing information sites, such as ribosome binding sites, RNA splice sites, polyadenylation sites, and transcriptional terminator sequences. Preferred expression control sequences are promoters

derived from immunoglobulin genes, SV40, adenovirus, bovine papilloma virus, cytomegalovirus and the like.

[00130] Antibody-coding sequences can be incorporated in transgenes for introduction into the genome of a transgenic animal and subsequent expression in the milk of the transgenic animal. Suitable transgenes include coding sequences for light and/or heavy chains in operable linkage with a promoter and enhancer from a mammary gland specific gene, such as casein or beta lactoglobulin.

[00131] Vectors containing the polynucleotide sequences of interest (e.g., the heavy and light chain encoding sequences and expression control sequences) can be transferred into the host cell by well-known methods, which vary depending on the type of cellular host. For example, calcium chloride transfection is commonly utilized for prokaryotic cells, whereas calcium phosphate treatment, electroporation, lipofection, biolistics or viral-based transfection may be used for other cellular hosts. Other methods used to transform mammalian cells include the use of polybrene, protoplast fusion, liposomes, electroporation, and microinjection (see generally, Sambrook et al., supra). For production of transgenic animals, transgenes can be microinjected into fertilized oocytes, or can be incorporated into the genome of embryonic stem cells, and the nuclei of such cells transferred into enucleated oocytes.

[00132] When heavy and light chains are cloned on separate expression vectors, the vectors are co-transfected to obtain expression and assembly of intact immunoglobulins. Once expressed, the whole antibodies, their dimers, individual light and heavy chains, or other immunoglobulin forms of the present disclosure can be purified according to standard procedures of the art, including ammonium sulfate precipitation, affinity columns (e.g., Protein A), column chromatography, HPLC purification, gel electrophoresis and the like. Substantially pure immunoglobulins of at least about 90 to 95% homogeneity are preferred, and 98 to 99% or more homogeneity most preferred, for pharmaceutical uses.

[00133] Increasing the copy number of expression vectors containing polynucleotide sequences of interest is desirable as a way to increase the production of antibodies or antibody fragments. A number of ways to genetically manipulate cells for this purpose and subsequently select the best cells are known in the art. These methods often include an “amplification” step to increase the copy number of the incorporated expression vector to

improve the yield obtained for the desired protein. Amplification methods have been previously reported, e.g., by Bebbington and Hentschel (DNA Cloning Volume III (IRL press, 1987)). Any of a number of selectable markers, often in the form of nucleic acid sequences that encode enzymes that are involved in host cell metabolism and are essential for their survival under certain media conditions, can be operably linked to an expression vector, whereby the expression of a desired protein can be promoted upon selection for a selectable marker. Cells selected for a high copy number can be subjected to further amplification methods when the titer of the protein is not acceptably elevated. Such methods can involve subjecting the cells to certain toxic drugs that inhibit the selectable marker (e.g., methotrexate and dihydrofolate reductase, methionine sulfoximine and glutamine synthase, multidrug resistance / adriamycin). Through such inhibition, cell populations with increased levels of expression of this marker may be selected. This often leads to increased expression levels of similarly functionally linked expression cassettes. Vector copy number in individual cells subjected to the amplification method are assessed until a plateau of protein production is reached, preferably at least about 100 mg/ml/10⁶ cells/24hours. Clones that grow through such selection and amplification are subsequently screened for titer / yield to select the best clone and then further evaluated. From such titration and screening, it is common to identify one or a small number of clones for subsequent production of one or more desired proteins and subsequently use it or them alone.

[00134] Pharmaceutical Compositions

[00135] Several methods of preparing and administering anti-A β antibodies, or antigen-binding fragments, variants, or derivatives thereof to a subject in need thereof are known. The route of administration of an anti-A β antibody, or antigen-binding fragment, variant, or derivative thereof, can be, for example, peripheral, oral, central (e.g., intrathecal, intracranial), parenteral, by inhalation or topical.

[00136] As discussed herein, anti-A β antibodies, or antigen-binding fragments, variants, or derivatives thereof can be formulated so as to facilitate administration and promote stability of the active agent. In certain embodiments, pharmaceutical compositions in accordance with the present disclosure comprise a pharmaceutically acceptable, non-toxic, sterile carrier such as physiological saline, non-toxic buffers, preservatives and the like. For the purposes of the instant application, a pharmaceutically effective amount of an anti-A β antibody, or antigen-binding fragment, variant, or derivative thereof, shall be held to mean an amount sufficient to

achieve effective binding to a target and to achieve a benefit, e.g., reduce brain amyloid plaques without affecting vascular amyloid, or minimizes the occurrence of microhemorrhage during chronic dosing of the anti-A β antibody or antigen-binding fragment thereof. In some embodiments, an anti-A β antibody or antigen-binding fragment, variant, or derivative thereof can cross the blood-brain barrier in an effective amount to reduce brain amyloid plaques.

[00137] The pharmaceutical compositions used in this disclosure comprise pharmaceutically acceptable carriers, including, e.g., ion exchangers, alumina, aluminum stearate, lecithin, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycine, sorbic acid, potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulfate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate, polyvinyl pyrrolidone, cellulose-based substances, polyethylene glycol, sodium carboxymethylcellulose, polyacrylates, waxes, polyethylene-polyoxypropylene-block polymers, polyethylene glycol, and wool fat.

[00138] Prevention of the action of microorganisms can be achieved by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, ascorbic acid, thimerosal and the like. In many cases, isotonic agents can be included, for example, sugars, polyalcohols or salts in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

[00139] Parenteral formulations can be a single bolus dose, an infusion or a loading bolus dose followed with a maintenance dose. These compositions can be administered at specific fixed or variable intervals, e.g., once a day, or on an "as needed" basis.

[00140] Preparations for parenteral administration include sterile aqueous or non-aqueous solutions, suspensions, and emulsions. Examples of non-aqueous solvents are propylene glycol, polyethylene glycol, vegetable oils such as olive oil, and injectable organic esters such as ethyl oleate. Aqueous carriers include water, alcoholic/aqueous solutions, emulsions or suspensions, including saline and buffered media. Parenteral vehicles include sodium chloride solution, Ringer's dextrose, dextrose and sodium chloride, lactated Ringer's, or fixed oils. Intravenous vehicles include fluid and nutrient replenishers, electrolyte replenishers (such as those based on Ringer's dextrose), and the like. Preservatives and other additives can

also be present such as, for example, antimicrobials, anti-oxidants, chelating agents, and inert gases and the like. Furthermore, the pharmaceutical composition of the disclosure can comprise further agents such as dopamine or psychopharmacologic drugs, depending on the intended use of the pharmaceutical composition.

[00141] The amount of an anti-A β antibody, or fragment, variant, or derivative thereof, to be combined with the carrier materials to produce a single dosage form will vary depending upon the host treated and the particular mode of administration. The composition can be administered as a single dose, multiple doses or over an established period of time in an infusion. Dosage regimens also can be adjusted to provide the optimum desired response (e.g., a therapeutic or prophylactic response).

[00142] The term “peripheral administration” as used herein includes, e.g., intravenous, intraarterial, intraperitoneal, intramuscular, subcutaneous, intranasal, intra-ocular/vitreous, rectal, or vaginal administration. While all these forms of administration are clearly contemplated as being within the scope of the disclosure, an example of a form for administration would be a solution for injection, in particular for subcutaneous, intravenous or intraarterial injection or drip. A suitable pharmaceutical composition for injection can comprise a buffer, a surfactant, optionally a stabilizer agent, etc. Preparations for peripheral administration include sterile aqueous or non-aqueous solutions, suspensions, and emulsions. Preservatives and other additives can also be present such as, for example, antimicrobials, antioxidants, chelating agents, and inert gases and the like.

[00143] Therapeutic compositions of the disclosure are typically substantially pure from undesired contaminants. This means that the agent is typically at least 50% w/w pure of interfering proteins and other contaminants arising from its production or purification but does not exclude the possibility that the agent is combined with an excess of pharmaceutical acceptable carrier(s) or other vehicle intended to facilitate its use. Sometimes monoclonal antibodies (or other therapeutic agents) are at least 60%, 70%, 80%, 90%, 95% or 99% w/w pure of interfering proteins and contaminants from production or purification.

[00144] Treatment Amenable Patients

[00145] The present disclosure is also directed to treatment of Alzheimer's and other amyloidogenic diseases by administration of the antibodies, fragments and pharmaceutical compositions of the disclosure generate a beneficial therapeutic response in a patient (e.g.,

induction of phagocytosis of A β , reduction of plaque burden, inhibition of plaque formation, reduction of neuritic dystrophy, neutralization of soluble, toxic A β species, improving cognitive function, and/or reversing, treating or preventing cognitive decline) in the patient, for example, for the prevention or treatment of an amyloidogenic disease. The disclosure is also directed to use of the disclosed antibodies and fragments in the manufacture of a medicament for the treatment or prevention of an amyloidogenic disease.

[00146] In one aspect, the disclosure provides methods of preventing or treating a disease associated with amyloid deposits of A β in a patient. In one aspect, the amyloid deposits are in the brain or other CNS areas. Such diseases include Alzheimer's disease, Down's syndrome, age-related macular degeneration (AMD), and cognitive impairment. The latter can occur with or without other characteristics of an amyloidogenic disease. Some methods of the disclosure entail administering an effective dosage of an antibody that specifically binds to a component of an amyloid deposit to the patient. Such methods are useful for preventing or treating Alzheimer's disease in human patients

[00147] The methods can be used on both asymptomatic patients and those currently showing symptoms of disease. The antibodies used in such methods can be humanized, human or fragments thereof (e.g., antigen binding fragments) and can be monoclonal or polyclonal, as described herein. In yet another aspect, the disclosure features administering antibodies prepared from a human immunized with A β peptide, which human can be the patient to be treated with antibody.

[00148] In another aspect, the disclosure features administering an antibody with a pharmaceutical carrier as a pharmaceutical composition. Alternatively, the antibody can be administered to a patient by administering a polynucleotide encoding at least one antibody chain. The polynucleotide is expressed to produce the antibody chain in the patient. Optionally, the polynucleotide encodes heavy and light chains of the antibody. The polynucleotide is expressed to produce the heavy and light chains in the patient. In exemplary embodiments, the patient is monitored for level of administered antibody in the blood of the patient.

[00149] Patients amenable to treatment include individuals at risk of disease but not showing symptoms, as well as patients presently showing symptoms. In the case of Alzheimer's disease, potentially anyone who lives long enough is at risk of Alzheimer's

disease. Thus, the present methods include administering prophylactically to the general population without the need for any assessment of the risk of the subject patient. The present methods are especially useful for individuals who have a known genetic risk of Alzheimer's disease. Such individuals include those having relatives who have experienced this disease, and those whose risk is determined by analysis of genetic or biochemical markers. Genetic markers of risk toward Alzheimer's disease include mutations in the APP gene, particularly mutations at position 717 and positions 670 and 671 referred to as the Hardy and Swedish mutations, respectively. Other markers of risk are mutations in the presenilin genes, PS1 and PS2, and ApoE4, family history of AD, hypercholesterolemia or atherosclerosis. Individuals presently suffering from Alzheimer's disease can be recognized from characteristic dementia, as well as the presence of risk factors described above. In addition, a number of diagnostic tests are available for identifying individuals who have AD. These include measurement of CSF tau and A β 42 levels. Elevated tau and decreased A β 42 levels signify the presence of AD. Individuals suffering from Alzheimer's disease can also be diagnosed by ADRDA criteria as discussed in the Examples section.

[00150] Treatment in asymptomatic patients can begin at any age (e.g., 10, 20, 30). Usually, however, it is not necessary to begin treatment until a patient reaches 40, 50, 60, or 70. Treatment typically entails multiple dosages over a period of time. Treatment can be monitored by assaying antibody levels over time. If the response falls, a booster dosage is indicated. In the case of potential Down's syndrome patients, treatment can begin antenatally by administering therapeutic agent to the mother or shortly after birth.

[00151] In vivo Detection

[00152] In another aspect, the disclosure provides methods for detecting amyloid plaques and deposits in a patient having or at risk of developing an amyloidogenic disease. Such methods are useful for diagnosing or confirming amyloidogenic disease or susceptibility to it. For example, the methods can be used in patients with dementia symptoms, wherein observation of abnormal amyloid deposits likely indicates Alzheimer's disease. The methods can also be used in asymptomatic patients. The presence of abnormal deposits of amyloid indicates susceptibility to future symptomatic disease.

[00153] In some embodiments, the method comprises administering to a subject/patient an antibody or fragment thereof of the disclosure and detecting the antibody or fragment thereof bound to A β .

[00154] Antibody and/or antibody fragments thereof can be administered by any suitable means that results in delivery to the tissue to be visualized, e.g., administered directly into the brain by intravenous injection into the patient's body or by intracranial injection. Dosage of the antibody and/or fragment thereof can comprise a therapeutic dose, subtherapeutic dose or a supratherapeutic dose. In some embodiments the antibody or fragment thereof is labeled, comprising a fluorescent label, a paramagnetic label, or a radioactive label. The choice of label depends on the means of detection. For example, fluorescent labels are suitable for visual detection. The use of paramagnetic labels is suitable for tomographic detection without surgical intervention. In some embodiments, the radioactive label is detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).

[00155] In another aspect, the disclosure provides methods for measuring the efficacy of treatment in a subject being treated for an amyloidogenic disease. In some embodiments, a first level of amyloid plaque in a subject is measured prior to treatment by administering an antibody or fragment thereof of the disclosure and detecting a first amount of the antibody or fragment thereof bound to A β in the subject. A treatment can then be administered to the subject, followed by measuring a second level of amyloid plaque in the subject, and detecting the antibody or fragment thereof bound to A β in the subject. In some embodiments, a decrease in the level of amyloid plaque indicates a positive response to treatment, and in some embodiments, no change in the level of amyloid plaque or a small increase in amyloid plaque indicates a positive response to treatment. In some embodiments, levels of amyloid plaque can be measured utilizing the methods of detecting amyloid plaques described herein.

[00156] In some embodiments, diagnosis of an amyloidogenic disease can be performed, for example, by comparing the number, size and/or intensity of labeled positions from a measured first level (i.e., baseline) to a subsequent second level of amyloid plaque in a subject. An increase over time indicates disease progression, no change indicates , and fewer or less intense amyloid plaques over time indicates remission.

[00157] Treatment Regimes

[00158] Prophylactic applications: pharmaceutical compositions or medicaments are administered to a patient susceptible to, or otherwise at risk of, Alzheimer's disease or other amyloidogenic disease in an amount sufficient to eliminate or reduce the risk, lessen the severity, or delay the onset of the disease, including biochemical, histologic and/or behavioral symptoms of the disease, its complications and intermediate pathological phenotypes presenting during development of the disease. Patient susceptibility or risk for developing an amyloidogenic disease can be determined, for example, from a genetic marker, a biochemical marker, unspecified hereditary risk or other means. In therapeutic applications, compositions or medicaments are administered to a patient suspected of, or already suffering from such a disease in an amount sufficient to cure, or at least partially arrest, the symptoms of the disease (biochemical, histologic and/or behavioral), including its complications and intermediate pathological phenotypes in development of the disease.

[00159] In some embodiments, administration of agent reduces or eliminates cognitive impairment in patients that have not yet developed characteristic Alzheimer's, or other amyloidogenic disease cognitive pathology. An amount adequate to accomplish therapeutic or prophylactic treatment is defined as a therapeutically- or prophylactically-effective dose. In both prophylactic and therapeutic regimes, agents are usually administered in several dosages until a sufficient immune response has been achieved, where "immune response" or "immunological response" includes the development of a humoral (antibody mediated) and/or a cellular (mediated by antigen-specific T cells or their secretion products) response directed against an antigen in a recipient subject. Such a response can be an active response, i.e., induced by administration of immunogen, or a passive response, i.e., induced by administration of immunoglobulin or antibody or primed T-cells.

[00160] In some embodiments, antibody is administered on multiple occasions. Intervals between single dosages can be weekly, monthly or yearly. Intervals can also be irregular as indicated by measuring blood levels of antibody to A β in the patient. In some methods, dosage is adjusted to achieve a plasma antibody concentration of 1-1000 μ g/ml and in some methods 25-300 μ g/ml. Alternatively, antibody can be administered as a sustained release formulation, in which case less frequent administration is required. Dosage and frequency vary depending on the half-life of the antibody in the patient. In general, human antibodies show the longest half-life, followed by humanized antibodies, chimeric antibodies, and nonhuman antibodies.

[00161] The dosage and frequency of administration can vary depending on whether the treatment is prophylactic or therapeutic. In prophylactic applications, compositions containing the present antibodies or a cocktail thereof are administered to a patient not already in the disease state to enhance the patient's resistance. Such an amount is defined to be a "prophylactic effective dose." In this use, the precise amounts again depend upon the patient's state of health and general immunity, but generally range from 0.1 to 25 mg/kg per dose, especially 0.5 to 2.5 mg/kg per dose. A relatively low dosage is administered at relatively infrequent intervals over a long period of time. Some patients continue to receive treatment for the rest of their lives.

[00162] In therapeutic applications, a relatively high dosage (e.g., from about 0.5 to 300 mg/kg of antibody per dose, with dosages of from 5 to 25 mg/kg being more commonly used) at relatively short intervals is sometimes required until progression of the disease is reduced or terminated, and preferably until the patient shows partial or complete amelioration of symptoms of disease. Thereafter, the patient can be administered a prophylactic regime.

[00163] Administration: therapeutic agents can be administered by parenteral, topical, intravenous, oral, subcutaneous, intraarterial, intracranial, intraperitoneal, intranasal, intraocular or intramuscular means for prophylactic and/or therapeutic treatment. Intramuscular injection is most typically performed in the arm or leg muscles. In some methods, agents are injected directly into a particular tissue where deposits have accumulated, for example intracranial injection. Intramuscular injection or intravenous infusion are preferred for administration of antibody. In some methods, particular therapeutic antibodies are injected directly into the cranium. In some methods, antibodies are administered as a sustained release composition or device.

[00164] Agents of the disclosure can optionally be administered in combination with other agents that are at least partly effective in treatment of amyloidogenic disease. In the case of Alzheimer's and Down's syndrome, in which amyloid deposits occur in the brain, agents of the disclosure can also be administered in conjunction with other agents that increase passage of the agents of the disclosure across the blood-brain barrier.

[00165] The present disclosure will be more fully described by the following non-limiting examples.

[00166] SEQ ID NO. 40: hIgG1 Constant

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL
YSLSSVTVTPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVF
LFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVV
SVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSL
TCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCSSV
MHEALHNHYTQKSLSLSPGK

[00167] SEQ ID NO. 41: huKappa Constant

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSK
DSTYLSLSSTLTLSKADYEEKHKVYACEVTHQGLSSPVTKSFNREGC

[00168] SEQ ID NO. 42: h2726_VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTTCTGGAGAGCGGGGGCGGCCCTGGTGCAGCCGGGCGGATCCCTGAGACTGTC
CTGTGCCGCGTCCGGTTTTACCTTCTCCAACTACGGAATGTCATGGGTCCGCCAAGCACCCG
GAAAGGGATTGGAATGGGTGGCTTCGATCCGGTCCGGCTCGGGACGGACCTACTACTCCGAT
AACGTCAAGGCGAGATTCACTATTAGCCGGGACAACAGCAAGAATACCCTGTACCTCCAAAT
GAACTCCCTGAGGGCCGAGGACACCGCCGTGTATTACTGCGTGCGCTACGACCACTACTCGG
GTTCTCTGATTACTGGGGACAGGGGACCCTCGTGACTGTGTCAAGC

[00169] SEQ ID NO. 43: h2726_VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACCCAGTCACCACTGTCCCTTCTCTGTGACTCCCGGAGAACC GGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGCTCGATTATGACGGAAAGACCTACCTGAACTGGTTGC
TCCAAAAGCCTGGGCAGAGCCCCAGAGACTGATCTACAAAGTGTC AACAGGGACTCGGGC
GTGCCGGACCGCTTCTCGGGGTCCGGTTCCGGTACCGACTTTACGCTGAAGATCTCACGGGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGCACTCACTTCCCGCGGACCTTCG
GACAAGGCACCAAGGTCGAGATCAAG

[00170] SEQ ID NO. 44: h2931_VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTCCTGGAGTCCGGGGGTGGACTGGTGCAGCCCGGGGGCAGCCTGAGGCTGAG
CTGCGCCGCGTCAGGATTACCTTCTCCAACTTCGGAATGTCCTGGGTGAGACAGGCCCCGG
GAAAGGGCCTTGAATGGGTGGCTAGCGTGCGCTCCGGTCCGGACGGACCTACTACTCGGAC
AACGTGAAGGGCCGGTTTTACTATCTCCCGGGACAATTCGAAGAACACCCTGTACCTCCAAAT

GAACTCCTTGCGCGCCGAGGATACCGCAGTGTATTACTGCGTGCGCTACGACCCTACTCTG
GCACTAGCGATTACTGGGGCCAGGGAAGTCTGGTCACCGTGTCTGCA

[00171] SEQ ID NO. 45: h2931_VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCACCTCTGTCCCTGCCTGTGACCCTTGGGGAACCCGCTCGAT
CTCGTGCAAGAGCTCCCAGAGCCTGCTCGACTATGATGGAAAGACCTACCTGAAGTGGTTGC
TCCAAAAGCCGGGCCAGAGCCCCAGAGGCTGATCTACCGCGTGACCAACCGCGACACCGGG
GTGCCGGACCGGTTCTCCGGATCCGGCAGCGGCACTGACTTCACCCTGAAAATTTCCAGAGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGTACTCACTTTCCACGGTCCTTCG
GTCAAGGAACCAAGGTCGAGATCAAG

[00172] SEQ ID NO. 46: h2731_VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTTCTGGAGAGCGGGGGCGGCCCTGGTGCAGCCGGGCGGATCCCTGAGACTGTC
CTGTGCCGCGTCCGGTTTTACCTTCTCCAACCTACGGAATGTCATGGGTCCGCCAAGCACCCG
GAAAGGGATTGGAATGGGTGGCTTCGATCCGGTCCGGCTCGGGACGGACCTACTACTCCGAT
AACGTCAAGGGCAGATTCACTATTAGCCGGGACAACAGCAAGAATACCCTGTACCTCCAAAT
GAACTCCCTGAGGGCCGAGGACACCGCCGTGTATTACTGCGTGCGCTACGACCCTACTCGG
GTTCTCTGATTACTGGGGACAGGGGACCCTCGTGACTGTGTCAAGC

[00173] SEQ ID NO. 47: h2731_VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCACCTCTGTCCCTGCCTGTGACCCTTGGGGAACCCGCTCGAT
CTCGTGCAAGAGCTCCCAGAGCCTGCTCGACTATGATGGAAAGACCTACCTGAAGTGGTTGC
TCCAAAAGCCGGGCCAGAGCCCCAGAGGCTGATCTACCGCGTGACCAACCGCGACACCGGG
GTGCCGGACCGGTTCTCCGGATCCGGCAGCGGCACTGACTTCACCCTGAAAATTTCCAGAGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGTACTCACTTTCCACGGTCCTTCG
GTCAAGGAACCAAGGTCGAGATCAAG

[00174] SEQ ID NO. 48: h2831_VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTGCTGGAGTCTGGCGGCGGACTGGTGCAGCCCGGGGGATCCCTGCGGCTTTC
CTGCGCCGCATCCGGCTTCACCTTTTCAAACCTTCGGAATGTCGTGGGTGAGACAGGCCCCGG
GAAAGGGTCTGGAATGGGTGGCTCAGTGCAGTCCGGATCGGGTAGAACCTACTACAGCGAT
AACGTGAAGGGCCGGTTCACGATCTCCCGCGACAACCTCCAAGAACACCCTGTACTTGCAAAT

GAATAGCCTCAGGGCTGAGGATACCGCGGTCTACTACTGTGTGCGCTATGACCACTACACTG
GAACTAGCGACTACTGGGGCCAGGGGACCCTCGTGACTGTGTCGTCC

[00175] SEQ ID NO. 49: h2831_VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCACCTCTGTCCCTGCCTGTGACCCTTGGGGAACCCGCTCGAT
CTCGTGCAAGAGCTCCCAGAGCCTGCTCGACTATGATGGAAAGACCTACCTGAACCTGGTTGC
TCCAAAAGCCGGGCCAGAGCCCCAGAGGCTGATCTACCGCGTGACCAACCGCGACACCGGG
GTGCCGGACCGGTTCTCCGGATCCGGCAGCGGCACTGACTTCACCCTGAAAAATTTCCAGAGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGTACTCACTTTCCACGGTCCTTCG
GTCAAGGAACCAAGGTCGAGATCAAG

[00176] SEQ ID NO. 50: h2926_VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTCCTGGAGTCCGGGGGTGGACTGGTGCAGCCCGGGGGCAGCCTGAGGCTGAG
CTGCGCCGCGTCAGGATTCACCTTCTCCAACCTTCGGAATGTCCTGGGTGAGACAGGCCCCGG
GAAAGGGCCTTGAATGGGTGGCTAGCGTGCGCTCCGGTTCGGGACGGACCTACTACTCGGAC
AACGTGAAGGGCCGGTTTACTATCTCCCGGGACAATTCGAAGAACACCCTGTACCTCCAAAT
GAACTCCTTGCGCGCCGAGGATACCGCAGTGTATTACTGCGTGCGCTACGACCACTACTCTG
GCACTAGCGATTACTGGGGCCAGGGAACCTCTGGTCAACCGTGTCTGTC

[00177] SEQ ID NO. 51: h2926_VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACCCAGTCACCACTGTCCCTTCTGTGACTCCCGGAGAACCGGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGCTCGATTATGACGGAAAGACCTACCTGAACCTGGTTGC
TCCAAAAGCCTGGGCAGAGCCCCAGAGACTGATCTACAAAGTGTC AACAGGGACTCGGGC
GTGCCGGACCGCTTCTCGGGGTCCGGTTCGGTACCGACTTTACGCTGAAGATCTCACGGGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGCACTCACTTCCCGCGGACCTTCG
GACAAGGCACCAAGGTCGAGATCAAG

[00178] SEQ ID NO. 52: h4921G VH (Variable Heavy) Nucleotide Sequence

GAGGTGCAGCTGCTGGAGTCGGGGGGGGGACTCGTGAGCCCGGGGGCTCCCTGAGACTCTC
TTGTGCCGCCTCCGGCTTCACTTTTTTCAAACCTTCGGAATGTCCTGGGTCCGCCAAGCACCGG
GAAAGGGTCTGGAATGGGTGCCAGCGTGCGGTCCGGCGGCGGACGGACTTACTACTCCGAC
AACGTGAAGGGCCGGTTCACCATCTCAAGGGATAACTCCAAGAATACTCTGTACTTGCAAAT

GAAC TCGCTGCGCGCTGAAGATACCGCGGTGTACTATTGCGTGCGCTACGACCACTACTCCG
GTACCAGCGACTACTGGGGACAGGGAACCCCTTGTGACCGTGTGAGC

[00179] SEQ ID NO. 53: h4921G VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCGCCCCCTCTCCCTGCCTGTGACTCTGGGGGAACCCGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGTTGGACTCAGACGGAAAGACCTACCTTAACTGGCTGC
TGCAAAAGCCAGGACAGAGCCCGCAGAGGCTGATCTACCGCGTGACCAACCGGGATACGGGA
GTGCCGGACAGATT CAGCGGCTCGGGTTCCGGCACCGACTTCACCCCTCAAAATCTCCCGCGT
CGAGGCCGAGGACGTGGGCGTGTATTACTGTTGGCAGGGAACCCACTTTCCTCGGACCTTCG
GTCAAGGGACTAAGGTCGAAATCAAG

[00180] SEQ ID NO. 54: h2826 VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTGCTGGAGTCTGGCGGCGGACTGGTGCAGCCCGGGGGATCCCTGCGGCTTTC
CTGCGCCGCATCCGGCTTCACCTTTTCAAACCTTCGGAATGTCGTGGGT CAGACAGGCCCCGG
GAAAGGGTCTGGAATGGGTGGCTCAGTGCGGTCCGGATCGGGTAGAACCTACTACAGCGAT
AACGTGAAGGGCCGGTTCACGATCTCCCGCGACAACCTCCAAGAACACCCTGTACTTGCAAAT
GAATAGCCTCAGGGCTGAGGATACCGCGGTCTACTACTGTGTGCGCTATGACCACTACACTG
GAACTAGCGACTACTGGGGCCAGGGGACCCTCGTGACTGTGTGCTCC

[00181] SEQ ID NO. 55: h2826 VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACCCAGTCACCACTGTCCCTTCTCTGTGACTCCCGGAGAACCGGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGCTCGATTATGACGGAAAGACCTACCTGAACTGGTTGC
TCCAAAAGCCTGGGCAGAGCCCCCAGAGACTGATCTACAAAGTGTC AACAGGGACTCGGGC
GTGCCGGACCGCTTCTCGGGGTCCGGTTCGGTACCGACTTTACGCTGAAGATCTCACGGGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGCACTCACTTCCCGCGGACCTTCG
GACAAGGCACCAAGGTCGAGATCAAG

[00182] SEQ ID NO. 56: h2929 VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTCCTGGAGTCCGGGGGTGGACTGGTGCAGCCCGGGGGCAGCCTGAGGCTGAG
CTGCGCCGCGTCAGGATTCACCTTCTCCAACTTCGGAATGTCCTGGGT CAGACAGGCCCCGG
GAAAGGGCCTTGAATGGGTGGCTAGCGTGCCTCCGGTTCGGACGGACCTACTACTCGGAC
AACGTGAAGGGCCGGTTTACTATCTCCCGGGACAATTCGAAGAACACCCTGTACCTCCAAAT

GAACTCCTTGCGCGCCGAGGATACCGCAGTGTATTACTGCGTGCGCTACGACCACTACTCTG
GCACTAGCGATTACTGGGGCCAGGGAAGTCTGGTCACCGTGTCTGTCA

[00183] SEQ ID NO. 57: h2929 VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACCCAAAGCCCCCTGTCCCTCCCTGTGACTCCTGGAGAGCCGGCGTCCAT
TTCCTGCCGGTCAAGCCAGTCCCTTGGTGGACTACGACGGAAGACCTACCTCAACTGGCTGC
TGCAGCGCCCCGGGCAGTCGCCGCAGCGGCTTATCTACAAAGTGTCGAACCGCGACTCGGGC
GTGCCGGATAGGTTTTCGGGTTCGGAAGCGGCACCGACTTCACCCTGAAAATCTCCAGAGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGTTCTCACTTCCCACGGTCATATG
GCCAAGGGACTAAGGTCGAAATCAAG

[00184] SEQ ID NO. 58: h3818G VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTCCTGGAGTCCGGCGGTGGACTGGTGCAGCCGGGCGGATCCCTGAGACTGTC
CTGCGCCGCGTCGGGCTTTACTTTTCGCAAATTACGGCATGAGCTGGGTGAGACAGGCCCCCG
GGAAGGGTCTGGAATGGGTGGCCAGCGTCCGGAGCGGGGGATCCCGGACCTATTACTCCGAC
AACGTGAAGGGCCGCTTCACCATCTCAAGGGACAACCTCCAAGAACACCCTGTACTTGCAAAT
GAACAGCCTTCGGGCTGAGGATACTGCCGTGTACTACTGCGTGCGCTACGACCACTACTCCG
GATCCTCGGATTACTGGGGACAGGGAACCCCTCGTGACCGTGTCTATCG

[00185] SEQ ID NO. 59: h3818G VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCGCCCCCTCTCCCTGCCTGTGACTCTGGGGGAACCCGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGATGGACACCGACGGAAGACCTACCTTAACTGGCTGC
TGCAAAAGCCAGGACAGAGCCCGCAGAGGCTGATCTACAAAGTGTCGAACCGGGAGTCCGGA
GTGCCGGACAGATTACGCGGCTCGGGTTCGGGCACCGACTTCACCCTGAAAATCTCCCGCGT
CGAGGCCGAGGACGTGGGCGTGTATTACTGTTGGCAGGGAACCCACTTTCCTCGGACCTTCG
GTCAAGGGACTAAGGTCGAAATCAAG

[00186] SEQ ID NO. 60: h2927 VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTCCTGGAGTCCGGGGGTGGACTGGTGCAGCCGGGGGCGAGCCTGAGGCTGAG
CTGCGCCGCGTCAGGATTACCTTCTCCAACCTTCGGAATGTCCTGGGTGAGACAGGCCCCCG
GAAAGGGCCTTGAATGGGTGGCTAGCGTGCGCTCCGGTTCGGGACGGACCTACTACTCGGAC
AACGTGAAGGGCCGCTTACTATCTCCCGGGACAATTCGAAGAACACCCTGTACCTCCAAAT

GAACCTCCTTGCGCGCCGAGGATACCGCAGTGTATTACTGCGTGCGCTACGACCCTACTCTG
GCACTAGCGATTACTGGGGCCAGGGAACCTCTGGTCACCGTGTCTGTCA

[00187] SEQ ID NO. 61: h2927 VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCACCGCTCTCCCTCCCTGTGACCCCGGGCGAACCAGCGTCGAT
CTCCTGCAAGAGCAGCCAATCATTTGCTGGACTACGACGGAAGACCTATCTTAACTGGCTGC
TGCAGAAGCCCGGGCAGAGCCCGCAGCGCCTGATCTACAAAGTGTCCAACAGAGACTCCGGA
GTGCCTGATAGGTTCTCGGGTTCGGGCTCCGGTACCGACTTCACTCTGAAAATTTCCCGGGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGCACCCACTTCCCCCGGTCTTTG
GACAAGGGACCAAGGTCGAGATCAAG

[00188] SEQ ID NO. 62: h49K3G VH (Variable Heavy) Nucleotide Sequence

GAGGTGCAGCTGCTGGAGTCGGGGGGGGGACTCGTGACGCCCGGGGGCTCCCTGAGACTCTC
TTGTGCCGCCTCCGGCTTCACTTTTTCAAACCTTCGGAATGTCCTGGGTCCGCCAAGCACCGG
GAAAGGGTCTGGAATGGGTGCGCAGCGTGCGGTCCGGCGGCGGACGGACTTACTACTCCGAC
AACGTGAAGGGCCGGTTCACCATCTCAAGGGATAACTCCAAGAATACTCTGTACTTGCAAAT
GAACCTCGCTGCGCGCTGAAGATACCGCGGTGTACTATTGCGTGCGCTACGACCCTACTCCG
GTACCAGCGACTACTGGGGACAGGGAACCCCTTGTGACCGTGTCTGAGC

[00189] SEQ ID NO. 63: h49K3G VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCGCCCCCTCTCCCTGCCTGTGACTCTGGGGGAACCCGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGTTGGACTCAGACGGAAGACCTACCTTAACTGGCTGC
TGCAAAAGCCAGGACAGAGCCCGCAGAGGCTGATCTACAAAGTGTCAAACCGGGATTCCGGA
GTGCCGGACAGATTACGCGGCTCGGGTTCGGGCACCGACTTCAACCTCAAAATCTCCCGCGT
CGAGGCCGAGGACGTGGGCGTGTATTACTGTTGGCAGGGAACCCACTTTCCTCGGACCTTCG
GTCAAGGGACTAAGGTCGAAATCAAG

[00190] SEQ ID NO. 64: h4917G VH (Variable Heavy) Nucleotide Sequence

GAGGTGCAGCTGCTGGAGTCGGGGGGGGGACTCGTGACGCCCGGGGGCTCCCTGAGACTCTC
TTGTGCCGCCTCCGGCTTCACTTTTTCAAACCTTCGGAATGTCCTGGGTCCGCCAAGCACCGG
GAAAGGGTCTGGAATGGGTGCGCAGCGTGCGGTCCGGCGGCGGACGGACTTACTACTCCGAC
AACGTGAAGGGCCGGTTCACCATCTCAAGGGATAACTCCAAGAATACTCTGTACTTGCAAAT

GAAC TCGCTGCGCGCTGAAGATACCGCGGTGTACTATTGCGTGCGCTACGACCACTACTCCG
GTACCAGCGACTACTGGGGACAGGGAACCCCTTGTGACCGTGTGAGC

[00191] SEQ ID NO. 65: h4917G VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCGCCCCCTCTCCCTGCCTGTGACTCTGGGGGAACCCGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGTTGGACTCAGACGGAAAGACCTACCTTAACTGGCTGC
TGCAAAAGCCAGGACAGAGCCCGCAGAGGCTGATCTACAAAGTGACCAACCGGGAGTCCGGA
GTGCCGGACAGATT CAGCGGCTCGGGTTCGGCACCGACTTCACCCCTCAAAATCTCCCGCGT
CGAGGCCGAGGACGTGGGCGTGTATTACTGTTGGCAGGGAACCCACTTTCCTCGGTCAATTCG
GTCAAGGGACTAAGGTCGAAATCAAG

[00192] SEQ ID NO. 66: h2727 VH (Variable Heavy) Nucleotide Sequence

GAAGTGCAGCTTCTGGAGAGCGGGGGCGGCCCTGGTGCAGCCGGGCGGATCCCTGAGACTGTC
CTGTGCCGCGTCCGGTTTTACCTTCTCCAACTACGGAATGTCATGGGTCCGCCAAGCACCCG
GAAAGGGATTGGAATGGGTGGCTTCGATCCGGTCCGGCTCGGGACGGACCTACTACTCCGAT
AACGTCAAGGGCAGATTCACTATTAGCCGGGACAACAGCAAGAATACCCTGTACCTCCAAAT
GAAC TCCCTGAGGGCCGAGGACACCGCCGTGTATTACTGCGTGCGCTACGACCACTACTCGG
GTTCTCTGATTACTGGGGACAGGGGACCCTCGTGACTGTGTCAAGC

[00193] SEQ ID NO. 67: h2727 VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCACCGCTCTCCCTCCCTGTGACCCCGGGCGAACCAGCGTCGAT
CTCCTGCAAGAGCAGCCAATCATTGCTGGACTACGACGGAAAGACCTATCTTAACTGGCTGC
TGCAGAAGCCCGGGCAGAGCCCGCAGCGCCTGATCTACAAAGTGTC AACAGAGACTCCGGA
GTGCCTGATAGTTCTCGGGTTCGGGCTCCGGTACCGACTTCACTCTGAAAATTTCCCGGGT
GGAAGCCGAGGACGTGGGAGTGTACTACTGTTGGCAGGGCACCCACTTCCCCCGGTGTTTTG
GACAAGGGACCAAGGTCGAGATCAAG

[00194] SEQ ID NO. 68: h4918G VH (Variable Heavy) Nucleotide Sequence

GAGGTGCAGCTGCTGGAGTCGGGGGGGGGACTCGTGACGCCCGGGGGCTCCCTGAGACTCTC
TTGTGCCGCTCCGGCTTCACTTTTTTCAAATTCGGAATGTCCTGGGTCCGCCAAGCACCCG
GAAAGGGTCTGGAATGGGTGCCAGCGTGCGGTCCGGCGGCGGACGGACTTACTACTCCGAC
AACGTGAAGGGCCGGTTCACCATCTCAAGGGATAACTCCAAGAATACTCTGTACTTGCAAAT

GAACTCGCTGCGCGCTGAAGATACCGCGGTGTACTATTGCGTGCGCTACGACCACTACTCCG
GTACCAGCGACTACTGGGGACAGGGAACCCCTTGTGACCGTGTTCGAGC

[00195] SEQ ID NO. 69: h4918G VL (Variable Light) Nucleotide Sequence

GATGTCGTGATGACTCAGTCGCCCCCTCTCCCTGCCTGTGACTCTGGGGGAACCCGCGTCCAT
TTCGTGCAAGAGCAGCCAGTCCCTGATGGACACCGACGGAAGACCTACCTTAACTGGCTGC
TGCAAAAGCCAGGACAGAGCCCGCAGAGGCTGATCTACAAAGTGTCAAACCGGGAGTCCGGA
GTGCCGGACAGATTACAGCGGCTCGGGTTCCGGCACCGACTTCACCCCTCAAAATCTCCCGCGT
CGAGGCCGAGGACGTGGGCGTGTATTACTGTTGGCAGGGAACCCACTTTCCTCGGACCTTCG
GTCAAGGGACTAAGGTCGAAATCAAG

[00196] SEQ ID NO. 70: Aducanumab Heavy Chain:

QVQLVESGGGVVQPGRSLRLSCAASGFAFSSYGMHWVRQAPGKGLEWVAVIWFDTGKKYYTD
SVKGRFTISRDN SKNTLYLQMNTLRAEDTAVYYCARDRGIGARRGPYYMDVWGKGTITVTVSS
ASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGL
YSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVKPKSCDKHTHTCPPCPAPELLGGPSVF
LFPPKPKDITLMISRTPPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVV
SVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTIKAKGQPREPQVYTLPPSREEMTKNQVSL
TCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSGDSFFLYSKLTVDKSRWQQGNVFCSCV
MHEALHNHYTQKSLSLSPGK

[00197] SEQ ID NO. 71: Aducanumab Light Chain:

DIQMTQSPSSLSASVGDRVTITCRASQSISSYLNWYQQKPGKAPKLLIYAASSLQSGVPSRF
SGSGSGTDFTLTITISLQPEDFATYYCQQSYSTPLTFGGGTKEIKRTVAAPSVEIFPPSDEQ
LKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDYSLSTLTLSKADY
EKHKVYACEVTHQGLSSPVTKSFNRGEC

[00198] SEQ ID NO. 72: Bapineuzumab HC (Heavy Chain)

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIRSGGGRTYYSD
NVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCVRYDHYSGSSDYWGQGLTVTVSSASTKG
PSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSS
VVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKHTHTCPPCPAPELLGGPSVFLFPPK
PKDITLMISRTPPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTV

LHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVK
GFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEAL
HNHYTQKSLSLSPGK

[00199] SEQ ID NO. 73: Bapineuzumab VH (Variable Heavy)

EVQLLESGGGLVQPGGSLRLSCAASGFTFSNYGMSWVRQAPGKGLEWVASIRSGGGRTYYSD
NVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCVRYDHYSGSSDYWGQGTTLTVSS

[00200] SEQ ID NO: 16: VH CDR1 GFTFSNYGMS

[00201] SEQ ID NO: 17: VH CDR2 SIRSGGGRTYYSDY NVKG

[00202] SEQ ID NO: 18: VH CDR3 YDHYSGSSDY

[00203] SEQ ID NO. 77: Bapineuzumab LC (Light Chain)

DVVMTQSPLSLPVTGPGEPAISCKSSQSLDSDGKTYLNWLLQKPGQSPQRLIYLVSKLD SG
VPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPRTFGQGTKVEIKRTVAAPSVFIFP
PSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSSTYLSSTLTTL
SKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

[00204] SEQ ID NO. 78: Bapineuzumab VL (Variable Light)

DVVMTQSPLSLPVTGPGEPAISCKSSQSLDSDGKTYLNWLLQKPGQSPQRLIYLVSKLD SG
VPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPRTFGQGTKVEIK

[00205] SEQ ID NO: 26: VL CDR1 KSSQSLDSDGKTYLN

[00206] SEQ ID NO: 27: VL CDR2 LVSSKLDS

[00207] SEQ ID NO: 28: VL CDR3 WQGTHFPRT

[00208] SEQ ID NO. 82: Gantenerumab HC amino acid sequence:

QVELVESGGGLVQPGGSLRLSCAASGFTFSYAMSWVRQAPGKGLEWVSAINASGTRTYAD
SVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARGKGNTHKPYGYVRYFDVWGQGTTLTV
SSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPS

VFLFPPKPKDITLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR
VVSFLTTLVHQLDNLGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQV
SLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSGDSFFLYSKLTVDKSRWQQGNVFC
SVMHEALHNHYTQKSLSLSPGK

[00209] SEQ ID NO. 83: Gantenerumab LC amino acid sequence:

DIVLTQSPATLSLSPGERATLSCRASQSVSSSYLAWYQQKPGQAPRLLIYGASSRATGVPAR
FSGSGSGTDFTLTITSSLEPEDFATYYCLQIYNMPITFGQGTKEIKRTVAAPSVFIFPPSDE
QLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSSTYSLSSTLTLSKAD
YEKHKVYACEVTHQGLSSPVTKSFNRGEC

[00210] SEQ ID NO. 84: Amyloid Beta (A β) 1-42:

DAEFRHDSGYEVHHQKLVFFAEDVGSNKGAIIGLMVGGGVIA

[00211] SEQ ID NO. 85: Amyloid Beta (A β) Precursor Protein:

MLPGLALLLLAAWTARALEVPTDGNAGLLAEPQIAMFCGRLLNMHMNVQNGKWDSDPSGKTCT
IDTKEGILQYCEVYPELQITNVVEANQPVTIQNWCKRGRKQCKTHPHFVIPYRCLVGEFVS
DALLVDPKCKFLHQRMDVCETHLHWHTVAKETCSEKSTNLHDYGMLLPCGIDKFRGVEFVC
CPLAEEEDNVDSADAEEDSDVWVGADTDYADGSEDKVVEVAEEEEVAEEEEEEADDEDD
EDGDEVEEEAEPEYEATERTTSIATTTTTTTTSESVEEVVREVCSEQAETGPCRAMISRWF
VTEGKCAPFFYGGCGGNRNNFDTEEYCMVCGSAMSQSLLKTTQEPLARDPVKLPTTAASTP
DAVDKYLETPGDENEHAHFQKAKERLEAKHRERMSQVMREWEAERQAKNLPKADKKAVIQH
FQEKVESLEQEAANERQQLVETHMARVEAMLNDRRLALENYITALQAVPPRPRHVFNMLKK
YVRAEQKDRQHTLKHFEHVRMVDPKKAAQIRSQVMTHLRVIYERMNQSLSLLYNVPAAVEEI
QDEVDELLQKEQNYSDVLNMISEPRISYGNLMPSLTETKTTVELLPVNGEFLDDLQP
WHSFGADSVANTENEVEPVDARPAADRGLTTRPGSGLTNIKTEEISEVKMDAEFRHDSGYE
VHHQKLVFFAEDVGSNKGAIIGLMVGGGVIAITVIVITLVMLKKKQYTSIHGVEVDAAVTP
EERHLSKMQQNGYENPTYKFFEQMQN

[00212] SEQ ID NO. 86: hIgG1 Constant Nucleotide Sequence

GCCAGCACTAAGGGGCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTGG
AACC GCGGCACTGGGGTGCCTCGTGAAGGACTACTTCCCCGAGCCGGTCACCGTGTCTGGA
ACTCGGGAGCCCTGACCTCCGAGTGCATACTTTCCCTGCGGTGCTGCAGTCTCCGGGCTC

TACTCGCTGTCAAGCGTGGTCACCGTCCCGAGCTCATCCCTGGGTACTCAGACCTACATTTG
 CAACGTGAACCACAAACCTTCCAACACCAAGGTCGACAAGAAAGTGGAGCCTAAGAGCTGCG
 ACAAGACCCACACCTGTCCCCCGTGTCCCGCCCCCTGAGCTGCTGGGCGGCCCCAGCGTGTTT
 CTCTTCCCGCCTAAGCCGAAGGACACTCTGATGATCTCGAGAACCCCTGAAGTGACCTGTGT
 GGTGGTGGATGTGTCCACGAGGATCCGGAAGTGAAGTTCAATTGGTACGTGGACGGAGTGG
 AAGTCCATAACGCCAAGACCAAGCCCCGCGAGGAACAGTACAACCTCAACTTACCGGGTGGTG
 TCAGTGCTGACCGTGCTGCACCAAGATTGGCTGAACGGGAAGGAGTACAAGTGCAAAGTCTC
 CAACAAGGCGCTGCCGGCCCCCATTTGAAAAGACCATCAGCAAGGCTAAGGGCCAGCCCCGGG
 AACCACAGGTCTACACCTTGCCCCCTTCCCGGGAGGAAATGACCAAGAACCAAGTGTGCTG
 ACGTGCTTGGTCAAGGGCTTTTATCCATCTGACATCGCCGTGGAGTGGGAAAGCAACGGCCA
 GCCGGAACAACTACAAGACTACCCCGCCTGTGCTGGACTCCGACGGCTCGTTCTTCTGT
 ATTCCAAGCTCACCGTGGATAAGTCCAGATGGCAGCAGGGCAATGTGTTTCAAGTGCAGCGTG
 ATGCATGAGGCCCTGCACAACCACTACACTCAGAAATCACTGTCCCTTTCCCCCGGAAAGTA
 A

[00213] SEQ ID NO. 87: huKappa Constant Nucleotide Sequence

CGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTGG
 AACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAGTGGA
 AGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTACAGAGCAGGACAGCAAG
 GACAGCACCTACAGCCTCAGCAGCACCCCTGACGCTGAGCAAAGCAGACTACGAGAAACACAA
 AGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCAACA
 GGGGAGAGTGTTAA

[00214] Examples

[00215] The following examples have been included to illustrate modes disclosed herein. Certain aspects of the following examples are described in terms of techniques and procedures found or contemplated by the present co-inventors to work well in the practice disclosed herein. In light of the present disclosure and the general level of skill in the art, those of skill appreciate that the following examples are intended to be exemplary only and that numerous changes, modifications, and alterations may be employed without departing from the scope of the disclosure.

[00216] “Aducanumab” or “Adu” as used in these experiments refers to an antibody with heavy chain of **SEQ ID NO: 70** and light chain of **SEQ ID NO: 71**, and as set forth in

United States patent publication number US 2015/0315267 and PCT publication number WO 2014/089500.

[00217] “BAN-2401” and “gantenerumab” as used in these experiments refer to an antibody with heavy chain of **SEQ ID NO: 79** and light chain of **SEQ ID NO: 80** as set forth, e.g., in European patent number EP 1960428B1.

[00218] In the following methods, antibody binding profiles to aggregated or fibrillar A β are characterized by ELISA, surface plasmon resonance (SPR) and immunohistochemistry (IHC). The ability to mediate phagocytic plaque clearance is evaluated *ex vivo* in APP/PS1 transgenic mouse brain as well as AD brain with primary murine microglia by immunofluorescence, ELISA and MSD quantification, and neutralization of A β oligomer neuronal binding is assessed in rat primary hippocampal cultures.

[00219] Results presented herein: relative to other N-terminal A β antibody therapies (bapineuzumab, aducanumab), mAbs of the description exhibited greater apparent affinity for aggregated and fibrillar A β in competition or standard binding ELISAs. The enhanced avidity of mAbs of the disclosure for fibrillar A β was confirmed by SPR equilibrium binding kinetics, indicating 5-11-fold higher avidity than aducanumab due to slower off-rate kinetics. IHC dose response assessments on frozen human AD brain sections showed greater apparent affinity and plaque area binding than aducanumab, regardless of the individual AD donor tissue tested. In *ex vivo* activity assays, mAbs of the disclosure were shown to significantly facilitate A β plaque reduction by microglial phagocytosis in APP/PS1 mouse tissue and to block soluble A β oligomer binding to rat primary neurons in a concentration-dependent manner. In *ex vivo* functional assays with human AD brain, mAbs from the description were shown to significantly facilitate clearance of pyroglutamylated A β , a post-translationally modified component of senile plaques.

[00220] Example 1. A β antibody design

[00221] A β antibody bapineuzumab (hBP) is a humanized antibody developed from parental murine antibody 3D6. Here, a multipronged approach was applied to construct superior antibodies to hBP. Humanness of hBP was analyzed and a determination was made that light chain humanization could be optimized.

[00222] A search was made over the protein sequences in the PDB database [Deshpande et al, 2005] to find structures that would provide a rough structural model of hBP. The crystal structure of hBP fab PDB code 4HIX [Miles, et al., 2013] was utilized for both Vh and Vk structure as it had acceptable resolution (2.2 Å) and an exact sequence match to hBP Vh and Vk, retaining the same canonical structures for the loops.

[00223] IMGT/DomainGapAlignment was performed for the hBP VL as input sequences. Human germ line VK gene sequence IGHV2-30*02 is the closest matched to hBP VL. The frameworks of hBP VL share a high degree of sequence similarity with the corresponding framework regions of IGHV2-30*02. Thus, the framework regions of IGHV2-30*02 VL were chosen as the guidance sequence for further optimization of the hBP framework regions. Additionally, three residues in CDR-L2 that do not make any direct contact with the antigen as per hBP 3D structure were also changed to germline sequence resulting in following changes, L50K, K53N and L54R (Kabat).

[00224] Three different versions of VL were designed by incorporating human germline framework residues into hBP VL sequence. Canonical or interface residues were not changed. An alignment of designed VK version designed is shown in Figure 1.

[00225] Based on structural observation that P15 is located at a turn and the germline gene has Leu at this position, P15L was tested in one version of the variable light chain.

[00226] Based on the 3D structural observations, substitutions at a number of residues in the light chain and heavy chain CDRs and framework were designed. In total thirty-one light chain and thirty-two heavy chain mutant VL and VH versions were generated and tested for binding in the first round of rational design. Mutations that showed improved binding were combined in the second round of the rational design. Additionally, new mutations guided by further analysis of the structure were also incorporated into the design.

[00227] Rational design based mutagenesis was done for following positions within CDR-H1, T28, S30, N31, Y32 and G33 (Kabat). For CDR-H2 positions I51, G53, G54, T57, S60, D61 and N62 were also mutated (Kabat). CDR-H3 positions D96, H97, S99, S100a and Y102 were subjected to rational mutagenesis (Kabat).

[00228] For variable light chain, multiple substitutions were tried at CDR-L1 positions K24, L27c, D27d and S27e (Kabat). Light chain CDR-L2 positions K53 and L54 were

subjected to directed and limited mutagenesis (Kabat). CDR-L3 positions were not subjected to substitutions.

[00229] A select few positions in the framework regions were also subjected to rational mutagenesis for heavy chain as well as light chain.

[00230] Fifty-seven additional heavy chain and thirty-three light chain variants were designed and analyzed with assistance of Atum GPSpro software, which analyzes database of human variable heavy and light chains and, based upon computer learning, suggests query sequence-specific changes.

[00231] For the variable heavy domain, a number of substitutions at positions A24, S25, G26, F27, T28, F29, S30, N31, Y32, G33 and M34 were designed and analyzed (Kabat). A majority of these positions were within CDR-H1. Similarly, many of the CDR-H2 residues were subjected to mutagenesis, such as positions A49, S50, I51, R52, S52a, G53, G54, G55, R56, T57, Y58, Y59, S60, D61, N62, V63 and K64 (Kabat). Additionally, multiple substitutions for the amino acids within CDR-H3 were made, for example, positions V93, R94, Y95, D96, H97, Y98, S99, G100, S100a, S100b, D101 and Y102 (Kabat).

[00232] Multiple substitutions were also designed for variable light chain CDR-L1 positions K24, S25, S26, Q27, S27a, L27b, L27c, D27d, S27e, D28, G29, K30, T31, Y32, L33 and N34 (Kabat). For CDR-L2, mutagenesis was performed at positions L50, V51, S52, K53, L54, D55 and S56 (Kabat). The majority of CDR-L3 positions such as Q90, G91, T92, H93, F94, P95, R96 and T97 were also rationally substituted with multiple amino acids (Kabat).

[00233] All variant antibodies resulting from rational as well as GPSpro design were analyzed for expression, melting point (T_m), affinity, and avidity. Eight antibodies from the rational design and six antibodies from the computer learning campaign were selected for further analysis based on the assays mentioned above.

[00234] Example 2. IC_{50} ratio determination by competitive ELISA assays.

[00235] An assay based on the competition (inhibition) of binding of a labeled antibody to an antigen-coated plate was used to determine IC_{50} for antibodies of the disclosure.

[00236] To generate fibrils, A β 1-42 polypeptides, previously treated with HFIP (hexafluoroisopropanol) and dried, were resuspended in DMSO to 5 mM, then further diluted to 100uM with 10 mM HCl. Samples were incubated at 37°C for 24h, and then centrifuged to separate soluble and fibrillar species. The pellet was the resuspended in 1x D-PBS to the original volume and sonicated before use.

[00237] Plates were coated with 0.5 mg/ml of fibril A β 42 and blocked, e.g., with 1% BSA/ PBS. Seven 3-fold dilutions of hBP starting at 150 μ g/ml (75 μ g/ml final concentration) and four 3-fold dilutions of test antibody starting at 20 μ g/ml (10 μ g/ml final concentration) prepared in 0.1%BSA/PBS were added to wells in triplicate, 50 μ l per well. 50 μ l of hBP-biotin at 0.75 μ g/ml (0.35 μ g/ml final concentration) prepared in 0.1%BSA/PBS was added to all wells and plates incubated 2 hours at room temperature then washed 3x with TTBS. 100 μ l of GE Streptavidin HRP diluted 1/10,000 was then added and incubated for 30 minutes. Plates were then washed 6x with TTBS. Thermo Fisher o-phenylenediamine dihydrochloride (OPD) substrate was prepared fresh per manufacturers direction, and 100 μ l per well was added. The reaction was incubated for 15 minutes and the reaction stopped with 50 μ l 2N H₂SO₄. Samples were read 490 nM on Spectromax. Figure 2, Figure 3 and Figure 4 illustrate competitive ELISA assay graphs for 4918, 4917, 4921, 3818, 49human3, 2931 and bapineuzumab control (Figure 2), 2926, 2831, 2927, 2726, 2731, 2826 and bapineuzumab control (Figure 3) and 2727, 2929 and bapineuzumab control (Figure 4). IC₅₀ for each test antibody are divided by the IC₅₀ for hBP to yield an half maximal inhibitory concentration (IC₅₀) ratio. A ratio of less than one indicates better performance than hBP. See Table 2.

Table 2

Antibody	Competition ELISA on fibril A β 42 IC ₅₀ ratio (test:hBP)
h2931	0.59
h2731	0.61
h2726	0.68
h2831	0.77
h2926	0.99
h4921	1.01
h2826	1.10
h2929	1.16
h3818	1.18
h2927	1.60
h49_hum3	2.16

h49_VK17	2.69
h2727	3.06
h4918	ND
hBP	1

[00238] Example 3. Monoclonal antibody potency determination by competitive ELISA

[00239] The binding potency of certain monoclonal antibodies of the disclosure and hBP was measured by their ability to compete with biotinylated-bapineuzumab bound to aggregated A β 42 was assessed by competition ELISA. One mg of A β 42 was added to 1 ml of diH₂O and was vigorously vortexed and placed on a nutator for 48 hours at room temperature. Plates were coated with 0.5 mg/ml of the heterogeneous A β 42 aggregate mixture and blocked, e.g., with 1% BSA/ PBS. Seven 3-fold dilutions of hBP starting at 150 μ g/ml (75 μ g/ml after dilution with hBP-Biotin) and four 3-fold dilutions of test antibody starting at 20 μ g/ml (10 μ g/ml after dilution with hBP-Biotin) were added to wells in triplicate, 50 μ l per well. 50 μ l of hBP-biotin at 0.75 μ g/ml (0.35 μ g/ml after dilution) was added to all wells and plates incubated 2 hours at room temperature then washed 3x with TTBS. 100 μ l of GE Streptavidin HRP diluted 1/10,000 was then added and incubated for 30 minutes. Plates were washed six times with TTBS. Thermo Fisher o-phenylenediamine dihydrochloride (OPD) substrate was prepared fresh per manufacturers direction, and 100 μ l per well was added. The reaction was incubated for 15 minutes and the reaction stopped with 50 μ l 2N H₂SO₄. Samples were read 490 nm on Spectromax. Figure 5A shows a competitive ELISA assay graph for 2931, 2731 and bapineuzumab control; Figure 5B shows a competitive ELISA assay graph for 2726, 2831 and bapineuzumab control. Figure 20A shows a competitive ELISA assay graph for 2931, 2731 and bapineuzumab control (data shown in Table 3, rows 1-2); Figure 20B shows a competitive ELISA assay graph for 2831, 2726 and bapineuzumab control (data shown in Table 3, rows 4-5). For Figure 20A and Figure 20B, curves and resulting IC₅₀ estimations represent nonlinear three-parameter least squares fit of data. Individual points are the average of triplicate samples (coefficient of variation <20%).

Table 3

mAb	Bapi	h2931	h2731
IC ₅₀ (μ g/mL mAb)	15.04	6.901	5.024

mAb	Bapi	h2726	h2831
IC ₅₀ (μg/mL mAb)	21.83	9.049	9.907

[00240] Results show that antibodies 2931, 2731, 2726, and 2831 showed greater potency than hBP; ~2-4 lower IC₅₀ values than hBP.

[00241] Example 4. Characterization of humanized mAbs or Fabs by BIAcore

[00242] To compare the binding characteristics of humanized antibodies or humanized antigen-binding fragments (Fab) to recombinant Aβ₁₋₄₂ fibrils, analysis was performed using a BIAcore T200 (GE Life Sciences).

[00243] To generate fibrils, Aβ₁₋₄₂ polypeptides, previously treated with HFIP (hexafluoroisopropanol) and dried, were resuspended in DMSO to 5 mM, then further diluted to 100μM with 10 mM HCl. Samples were incubated at 37°C for 24h, and then centrifuged to separate soluble and fibrillar species. The pellet was the resuspended in D-PBS to the original volume and sonicated before use.

[00244] Fibrils were immobilized on sensor chip CM5 (GE Healthcare Life Sciences) via amine coupling to a level to ensure a maximum binding of analyte of approximately 100 RU. Various concentrations of antibodies or Fabs (ranging from 1nM to 100nM) were passed over the coupled ligand at 30 μL/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA) for 300s association time and 1200s dissociation time. Regeneration of the chip surface was accomplished by 2 short injections of 10mM Glycine-HCl at pH 1.7. Data was blank-subtracted to both a sensor not containing ligand and 0 nM analyte concentration. Analysis was performed using a global 1:1 fit with BIAcore Insight Evaluation software (v2.0) with bulk refractive index set to zero RU. Off-rate data (k_{diss}; kd) are shown in Table 4 (Fabs) and Table 6 (antibodies).

[00245] Similar, small dissociation constants can be seen for the h2726, h2731, h2831 and h2931 Fabs and antibodies in comparison to aducanumab, which demonstrated a significantly larger dissociation constant.

Table 4

Injection variables Analyte 1 Solution	1:1 binding ka (1/Ms)	kd (1/s)	Apparent KD (M)	Rmax (RU)
h2726	1.29e+5	2.59e-4	2.01e-9	133.5
h2731	1.29e+5	2.89e-4	2.24e-9	134.0
h2831	1.08e+5	2.48e-4	2.31e-9	127.1
h2931	1.23e+5	1.99e-4	1.62e-9	132.0
hBP	1.12e+5	6.00e-4	5.34e-9	116.1

[00246] Example 5. Characterization of humanized mAbs affinity apparent by BIAcore

[00247] Determination of binding affinity of anti-A β candidates to A β ₁₋₂₈ (Bachem, Torrance, CA) was performed using a Biacore T200. Anti-human Fc antibody was immobilized to a CM3 sensor chip (GE Healthcare Life Sciences) via amine coupling and used to capture A β antibodies.

[00248] Various concentrations of A β ₁₋₂₈ (analyte, ranging from concentrations of 100 nM down to 0.39 nM, serial diluted 2-fold each dilution step) were passed over the captured ligand at 50 μ l/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA) for 240s association time and 900s dissociation time. Data were blank subtracted to both an irrelevant sensor not containing ligand, and buffer runs containing 0 nM analyte concentration. Analysis was performed using a global 1:1 fit with Biacore Evaluation software (v3.0).

[00249] Apparent dissociation constants (KD) are shown in Table 5, where mAbs of the disclosure demonstrated 4-7 nM binding affinity for A β ₁₋₂₈ monomer. Sensorgrams of binding at concentrations from 0.39 nM through 100nM are shown in Figure 6A (h2726), Figure 6B (h2731), Figure 6C (h2831) and Figure 6D (h2931).

Table 5

Injection variables Capture Solution	Analyte 1 Solution	1:1 binding ka (1/Ms)	kd (1/s)	Apparent KD (M)	Rmax (RU)
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h2726	A β ₁₋₂₈	9.23e+4	5.55e-4	6.01e-9	87.0
h2731	A β ₁₋₂₈	1.19e+5	5.95e-4	5.01e-9	78.3
h2831	A β ₁₋₂₈	7.31e+4	5.08e-4	6.95e-9	88.0
h2931	A β ₁₋₂₈	9.47e+4	4.12e-4	4.35e-9	76.1

[00250] Example 6. Characterization of humanized mAbs affinity apparent by BIAcore

[00251] To compare the binding characteristics of humanized antibodies to recombinant A β ₁₋₄₂ fibrils, analysis was performed using a BIAcore T200.

[00252] To generate fibrils, A β ₁₋₄₂ polypeptides, previously treated with HFIP (hexafluoroisopropanol) and dried, were resuspended in DMSO to 5 mM, then further diluted to 100 μ M with 10 mM HCl. Samples were incubated at 37°C for 24h, and then centrifuged to separate soluble and fibrillar species. The pellet was resuspended in 1x D-PBS to the original volume and sonicated before use.

[00253] Fibrils were immobilized on sensor chip CM5 (GE Healthcare Life Sciences) via amine coupling to a level to ensure a maximum binding of analyte of approximately 50 RU. Various concentrations of antibodies (ranging from 0.41 nM to 100 nM) were passed over the coupled ligand at 30 μ L/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA) for 300s association time and 1200s dissociation time. Regeneration of the chip surface was accomplished by 2 short injections of 10mM Glycine-HCl pH 1.7. Data was blank subtracted to both a sensor not containing ligand and 0 nM analyte concentration. Analysis was performed using a global 1:1 fit with BIAcore Insight Evaluation software (v2.0) with bulk refractive index set to zero RU. Apparent dissociation constant (KD) are shown in Table 6 and a comparison sensorgram of binding at 100nM is shown in Figure 7.

Table 6

Immobilized ligand	Injection variables Analyte 1 Solution	1:1 binding ka (1/Ms)	kd (1/s)	Apparent KD (M)	Rmax (RU)
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fibril A β 7.5 μ g/mL Ace4.5	Adu	2.96e+7	1.70e-2	5.74e-10	45.2
fibril A β 7.5 μ g/mL Ace4.5	h2726	3.93e+5	2.12e-5	5.40e-11	51.0
fibril A β 7.5 μ g/mL Ace4.5	h2731	3.72e+5	2.62e-5	7.04e-11	50.7
fibril A β 7.5 μ g/mL Ace4.5	h2831	2.65e+5	2.94e-5	1.11e-10	50.2
fibril A β 7.5 μ g/mL Ace4.5	h2931	3.35e+5	2.05e-5	6.12e-11	50.0

A β , amyloid beta, A β ; k_a , association rate constant; k_d , dissociation rate constant; K_D , apparent equilibrium dissociation constant; mAb, monoclonal antibody; R_{max} , maximum response; SPR, surface plasmon resonance.

[00254] The enhanced relative avidity of monoclonal antibodies of the disclosure for fibrillar A β observed by ELISA was confirmed by SPR equilibrium binding kinetics (Table 6), which indicated a 5- to 11-fold greater avidity (apparent K_D) than aducanumab.

[00255] This is explained by the different kinetic binding profiles observed in the SPR sensorgram (Figure 7). Although aducanumab binds A β fibrils at a faster association rate (k_a), the much slower dissociation rate (k_d) of the monoclonal antibodies of the disclosure resulted in greater measured avidity (i.e., lower K_D^*) than aducanumab.

[00256] **Example 7. A β fibril binding by ELISA**

[00257] The direct binding of certain monoclonal antibodies of the disclosure and aducanumab to A β_{1-42} and A β_{pE3-42} fibrils was assessed by ELISA. To generate fibrils, A β_{1-42} or A β_{pE3-42} polypeptides, previously treated with HFIP (hexafluoroisopropanol) and dried, were resuspended in DMSO to 5 mM, then further diluted to 100 μ M with 10 mM HCl. Samples were incubated at 37°C for 24h, and then centrifuged to separate soluble and fibrillar species. The pellet was resuspended in 1x D-PBS to the original volume and sonicated before use.

[00258] 1.0 μ g/ml or 2.5 μ g/ml of A β fibrils in PBS were coated overnight at room temperature. Plates were blocked 1% BSA/ PBS for 1 hour. Antibodies were serially diluted from 10 μ g/ml to 4.8 ng/ml in 0.1% BSA-PBS and 0.1% Tween 20 and 100 μ l of each dilution was added in duplicate to each antibody and incubated for 2 hrs at room temperature.

Plates were washed four times with TBS/Tween 20 and 100 μ l of goat anti Human IgG HRP (Jackson ImmunoResearch Laboratories, Inc, West Grove, PA or Invitrogen, Carlsbad, CA) at 1/5000 dilution was added to each well and incubated 1 hour at room temperature. Plates were wash six times in TBS/Tween 20, and Thermo Fisher o-phenylenediamine dihydrochloride (OPD) tablets and ThermoFisher substrate buffer were prepared per manufacturer's instructions. 100 μ l of substrate was added and incubated 15 min. Reaction was stopped with 50 μ l H₂SO₄. Plates were read at 490 nm on a molecular devices spectromax. Figure 9A, and Figure 21. For Figure 21, curves and resulting EC₅₀ estimations represent nonlinear three-parameter least squares fit of the data (data shown in Table 7).

Table 7

mAb	h2726	h2731	h2831	h2931	Adu
EC ₅₀ (μ g/mL mAb)	0.0359	0.03671	0.04894	0.04495	0.7241

[00259] Plates were coated with dilutions of A β fibrils in PBS from 10 μ g/ml to 4.8 ng/ml overnight at room temperature. Plates were blocked 1% BSA/ PBS 1 hour. Antibodies at 2 μ g/ml in 0.1%BSA/PBS 0.1% Tween 20 were added in duplicate to the appropriate wells and incubated for 2 hrs at room temperature. Plates were washed 4x with TBS/Tween 20 and then 100 μ l of Jackson Goat anti Human IgG HRP 1/5000 dilution was added to each well and incubated 1 hour at room temperature. Plates were wash six times in TBS/Tween 20, and Thermo Fisher o-phenylenediamine dihydrochloride (OPD) tablets and Thermofisher substrate buffer were prepared per manufacturer's instructions. 100 μ l of substrate was and incubated 15 min. Reaction was stopped with 50 μ l H₂SO₄. Plates were read at 490 nm on a molecular devices spectromax. Figure 9B, right panel.

[00260] Antibodies h2726, h2731, h2831 and h2931, all demonstrated strong affinities to fibrils, with the difference between best and worst performer within 25%. Additionally, these four antibodies all demonstrated significantly greater avidity than aducanumab. For Figure 21, a 3-fold increase in assay signal (OD₄₉₀) and a 15 to 20-fold lower estimated EC₅₀ indicated increased overall binding and relative avidity of h2726, h2731, h2831 and h2931 mAbs to fibrillar A β relative to aducanumab.

[00261] **Example 8. h2931 binding of A β oligomer by ELISA**

[00262] The direct binding of h2931 to A β oligomer was assessed by ELISA. To generate oligomers, first lyophilized biotinylated and unlabeled A β (Bachem) were each solubilized at 1 mg/mL in 1,1,1,3,3,3-hexafluoroisopropanol (HFIP, Sigma). HFIP was allowed to evaporate from the samples overnight in a fume hood at room temperature. Aliquots were then centrifuged in a speedvac at room temperature to remove all liquid to generate 250 μ g aliquots of HFIP films, which were stored at -80 °C until further use.

[00263] Oligomers were prepared by solubilizing 250 μ g of biotinylated and unlabeled A β HFIP pellets in dry DMSO (Sigma) to a final concentration of 5 mM. For unlabeled:biotinylated mixtures, samples were combined in a 9:1 ratio (unlabeled:biotinylated) in an sterile 1.5 mL low-binding microcentrifuge tube (Axygen). DMSO-solubilized samples were then diluted to 100 μ M with cold phenol-free neurobasal media (Invitrogen) and incubated for 24 hours at 4 °C. After incubation, the oligomers were separated from large insoluble material via centrifugation at 14,000 g for 15 minutes. The top 90% of the supernatant was carefully removed and placed in a new sterile low-binding microcentrifuge tube and stored on ice until use.

[00264] 2.5 μ g/mL of each preparation in PBS was coated 100 μ l per well in Costar ELISA high bind plates overnight at room temperature. Plates were aspirated and then 200 μ l of 1% BSA in PBS was added in each well and incubated 1 hour at room temperature. h2931 mAb was made at a starting concentration 10 μ g/ml in 0.1% BSA/PBS 0.1% tween 20 buffer and serially diluted seven times (1:2 each time) with the same. The samples were incubated for 2 hours at room temperature. Plates were washed 4 times with TBS.0.1% tween 20. Goat anti-human (H+L) HRP (Jackson Immunoresearch, PA) was diluted 1/5000 in 0.1% BSA/PBS 0.1% tween 20, added at 100 μ l/well and incubated 1 hour at room temperature. Plates were washed 4 times and o-phenylenediamine dihydrochloride tablets (ThermoFisher) were prepared as per manufacturer instructions. 100 μ l was added per well and incubated for 15 minutes at room temperature. Reactions were stopped by the addition of 50 μ l of H₂SO₄, and samples were read at 490 nM on a Molecular Devices SpectroMax. Curves and resulting EC₅₀ estimations represent nonlinear 3-parameter least-squares fit of data using GraphPad Prism software.

[00265] mAb h2931 was shown to bind soluble oligomers with high relative affinity, with an estimated EC₅₀ of 23 ng/mL or 0.15 nM. Figure 8.

[00266] Example 9. Anti-A β antibodies binding in AD brain

[00267] Tissue samples. Frozen human AD brain samples were obtained from Banner Sun Health Research Institute, Sun City, AZ. The tissues are from donors who were confirmed to have high amount of A β pathology and staged according to the Braak system at the provider institution (Table 8). In addition, quality control was performed in-house on all tissue blocks to ascertain their pathology level and distribution.

Table 8. AD donor information

Case ID	gender	Expired_age	PMI	Braak score
AD 13-75	M	77	3.62	VI
AD 14-11	M	82	3.98	V
AD 15-19	F	83	3.62	V
AD 11-97	F	86	2.52	V

[00268] Tissue Sectioning and Fixation. The unfixed frozen brain tissue samples were embedded in Tissue-Tek OCT (Sakura Finetek) in cryomolds dipped in a mixture of 2-methylbutane and dry ice slurry (-60°C) then stored at -80°C until sectioning. Serial 10 μ m thick cryosections were generated using a Leica 3050S cryostat. The sections were directly thaw-mounted on positively charged glass slides and were stored at -20°C until use. Prior to immunohistochemistry IHC procedures, the slides were immersed in 10% neutral buffered formalin solution for 10 minutes at 4°C, rinsed in PBS, then incubated for an hour at 37°C in a glucose oxidase solution (20 mM beta D(+) glucose, 2 mM sodium azide, and 2 units/mL glucose oxidase in 1X PBS). The slides were rinsed 3 times for 5 minutes in PBS before they were transferred onto staining racks for processing in an automated stainer.

[00269] Antibody biotinylation. The humanized IgG antibodies were biotinylated using a non-covalent method, by means of incubation with a biotin-conjugated goat anti-human monovalent fab fragment (Jackson ImmunoResearch) in a ratio of 1:4, for 1 hour at room temperature. Unbound excess Fab was absorbed by pre-incubation with human serum for an additional hour before use. The freshly prepared antibodies were then loaded into the stainer for immediate application to tissue sections.

[00270] Immunostaining. The staining was performed in an automated Leica Bond Rx Stainer (Leica Biosystems), using the Bond Research Kit (DS980, Leica Biosystems) and the avidin-biotin amplified immuno-peroxidase detection system. Each biotinylated anti-A β

antibody, or a human IgG control, was applied to the sections, at specified concentrations, for one hour and the staining was visualized using the avidin-biotin amplification system (ABC Elite Standard, PK-6100; Vector Laboratories). Hematoxylin counter-staining of nuclei was subsequently applied to sections before dehydration in an ascending series of alcohols, clearing in xylene, cover-slipping, and air-drying.

[00271] **Tissue imaging.** The stained slides were digitally imaged using a Hamamatsu NanoZoomer 2.0HT slide scanner (Hamamatsu Corporation), and the images were captured in an .ndpi file format using the NanoZoomer Digital Pathology software (NDP.scan, Version 2.7.25). Images included in this report were captured directly from NDP.view and transferred without any enhancement. For morphometry, the digitized slides were analyzed using Halo software (V2.1.1537) to measure the percentage of stained tissue, and the results were plotted using GraphPad Prism 8.

[00272] **Results with h2726, h2731, h2831, h2931 and aducanumab.** Four humanized anti-A β antibodies of the disclosure, h2726, h2731, h2831 and h2931, as well as aducanumab, were applied to all four AD brains at increasing concentrations: 0.03, 0.1, 0.3, 1, 3 and 9 μ g/ml. As shown in Figure 10 (0.3 μ g/mL), the AD brain sections that were incubated with these antibodies exhibited immunopositive structures that are typical for A β pathology in AD. Brains AD 13-75 and AD 14-11 have high density of A β plaques while the pathology in brains AD 11-97 and AD 15-19 was comparatively sparse. In each brain, the staining produced by the four antibodies, h2726, h2731, h2831 and h2931, at a specific concentration, was comparable in intensity and distribution. Staining with aducanumab was the weakest among samples and concentrations. As exemplified in Figure 11, sections from all four brains that were incubated with control human IgG isotype at 1 or 9 μ g/ml had no pathology staining.

[00273] The graphs in Figure 12 and Figure 22 are plots of the quantification of staining by the five antibodies in all four AD brains. Measurements of the percentage of tissue surface area that was occupied by the stained pathology confirm that, in each AD brain, the four antibodies, h2726, h2731, h2831, h2931, have similar levels of binding, at all concentrations tested. Correspondingly, the data in Table 9 show that, with each brain, the area under the curve and EC50 values remain comparable for the four antibodies. Values obtained with aducanumab were consistently lower among AD brains throughout the concentration range tested.

[00274] Figure 22 showed greater plaque area binding (as a percentage positive tissue stained) than aducanumab, notably, at antibody concentrations that are estimated to be clinically relevant exposures in cerebrospinal fluid with 10mg/kg aducanumab. Similar plaque area staining was observed at the highest concentration tested, suggesting saturation of binding at this level.

Table 9

Area under the curve and half maximal effective concentration (EC₅₀)

Area Under Curve	h2726	h2731	h2831	h2931
AD 11-97	50.18	50.58	49.21	47.70
AD 15-19	52.08	52.71	49.73	44.81
AD 13-75	149.3	150.4	138.7	139.1
AD 14-11	149.1	149.2	148.9	134.5
EC50	h2726	h2731	h2831	h2931
AD 11-97	0.09163	0.1346	0.1019	0.08893
AD 15-19	0.1356	0.1274	0.1328	0.1330
AD 13-75	0.1615	0.1415	0.2144	0.2273
AD 14-11	0.1325	0.1102	0.1625	0.1691

[00275] Results with bapineuzumab (hBP)

[00276] Section from brain AD 13-75 were incubated with the humanized antibody hBP as well as aducanumab and BAN2401 at increasing concentrations: 0.03, 0.1, 0.3, 1, 3 and 9 µg/ml. As seen with antibodies h2726, h2731, h2831 and h2931, the level of staining with hBP increased in a dose dependent manner. In addition, hBP staining was stronger than that of aducanumab and BAN2401 at all concentrations tested, as shown in Figure 13.

[00277] Example 10. *Ex vivo* phagocytosis assays for determination of (A β ₁₋₄₂ and A β _{pE3-42}) plaque clearance

[00278] In the early stages of AD, microglial function is neuroprotective, acting to clear apoptotic cells and pathological protein aggregates, as well as forming a barrier around plaques to restrict their growth and diffusion of synaptotoxic A β oligomers. *Ex vivo* phagocytosis assays quantitate the antibody-mediated microglial clearance response.

[00279] **Primary microglial culture generation:** For dissection of neonatal mouse brain tissue, P1 pups are quickly decapitated with sterile scissors. Meninges are removed and

forebrain were immediately immersed into 1-5 ml dissection media (e.g., high glucose DMEM with 20% FBS, P/S) on ice until the desired number of pup brains has been dissected. Preferably limit total procedure time to within 10 minutes to minimize cellular damage.

[00280] Tissue was carefully aspirated twice consecutively with new sterile pipettes using a 22G needle, followed by a 25G needle. Sample were centrifuged at 2,500x g for five minutes at 4 °C. Supernatant was carefully aspirated and 5 ml of fresh growth media was added (high-glucose DMEM, 10% FBS, P/S and 25 ng/ml recombinant mouse GM-CSF) to the cell pellets. The cell pellets are pipetted up and down approximately 10 times with a sterile 10 ml pipette to dissociate the pellets.

[00281] A cell strainer (100µm pores) was placed onto a fresh 50 ml conical tube and the material was dispensed through the cell strainer into the conical tube. The cell strainer was rinsed with 4-5 ml of fresh media, followed by centrifuging 200x g for five minutes at 4 °C.

[00282] Cells were plated at a density of two mouse brains per T-75 plastic culture flask. Carefully aspirate supernatant and add 3 ml of fresh growth medium (high-glucose DMEM, 10% FBS, P/S, and 25 ng/ml recombinant mouse GM-CSF) to each cell pellet with 10 ml sterile pipette. Pipette up and down 10 times with a 10 ml pipette to resuspend. Prepare 1 sterile T-75 flask by adding 6 ml of growth medium (high-glucose DMEM, 10% FBS, P/S and 25 ng/ml recombinant mouse granulocyte-monocyte colony-stimulating factor) into each flask, followed by the addition of 6 ml of resuspended cell pellets to obtain 12 ml final in a 5% CO₂ incubator at 37 °C.

[00283] Flasks are incubated undisturbed for five days to allow cells to attach. On the fifth day, the culture media was replaced in each flask with 12 ml of fresh growth medium (high-glucose DMEM, 10% FBS, P/S and 25 ng/ml recombinant mouse GM-CSF). Approximately 10% of the mixed cells plated will attach and grow on the plastic surface. The media was changed twice per week (every 3-4 days) to achieve confluence. Such changes are carried out with very carefully without touching the bottom of the flasks where the cells are attached.

[00284] After 7–11 d the flasks were rotated at 200 rpm using a Lab-Line orbital shaker with a 19-mm orbit for 2 h at 37 °C. Cell suspensions were centrifuged at 200x g and resuspended in assay medium (hybridoma-serum free medium H-SFM [Life Technologies] plus 1% FBS, glutamine, P/S, and 5 ng/ml recombinant mouse GM-CSF).

[00285] **Ex vivo assays.** Cryostat sections (10 μ m in thickness; use the wide blades) of APP/PS1 mouse or human AD brains (postmortem interval, less than 3 h) were ‘thaw mounted’ onto polylysine-coated, round glass coverslips and placed in wells of 24-well tissue culture plates (CT -30C OT -20C). Tissue samples can be warmed with thumb in between sections or by reducing OT to -12C). The coverslips were washed twice with assay medium. Antibodies (control or against A β) were added at a 2X concentration 250 μ l in assay medium (20 μ g/ml final) for 1 h in tissue culture incubator.

[00286] Microglial cells were then seeded at a final density of 800,000 cells/ml (1,600,000 cells/ml stock) in assay medium 250 μ l. The cultures were maintained in a humidified incubator at 37 °C in an atmosphere of 5% CO₂ for 72 hrs.

[00287] Quantification of total A β (A β ₁₋₄₂). Media was carefully aspirated, followed by washing with ice cold PBS. 100 μ l 8M urea was added and tissue resuspended by pipetting and scraped off with pipette tip. Suspension was then frozen at -20°C until ready for analysis. Suspensions were thawed on ice, centrifuged 16,000x g 20 min at 4°C before dilution and analysis using a V-PLEX Total A β 42 Peptide (4G8) Kit (Meso Scale Discovery). Results are shown in Figure 14A, Figure 14B and Figure 24. Figure 14A and Figure 24 show A β level per brain section and Figure 14B shows the same data as a scatter plot per treatment (data for Figure 14B shown in Table 10; data for Figure 24 shown in Table 11). h2731, h2931, and aducanumab demonstrated highly significant reductions in A β plaque species over isotype control.

Table 10

mAb (Avg. pg/mL A β ₁₋₄₂)	Isotype control	h2931	Aducanumab
Mean	92619	53113	49501
SD	14801	18239	7961

Table 11

Condition	A β 1-42 (pg/ml)	SD
Healthy control	5797.25	2022.51
AD brain + hIgG1 isotype	185138.90	35888.64
AD brain + h2731	101172.05	40194.48

[00288] Quantification of pyroglutamate-3 A β (A β _{pE3-42}). N-terminal truncated and pyroglutamate-modified A β (e.g., A β _{pE3-42}) has been described as a component of mature senile plaques in AD brain (Saido et al., Neuron 14, 1995). It was unknown whether pyroglutamate-modification of N-terminal A β would affect binding of N-terminal antibodies like h2731 and others described herein. Likewise, it was unknown whether these antibodies would have the ability to promote phagocytic-mediated clearance of A β _{pE3-42}.

[00289] The presence of pyroglutamate-3 A β in AD brain used for *ex vivo* experiments, as well as its similar staining pattern compared to h2931, was confirmed by immunohistochemistry (Figures 25A and 25B). To demonstrate removal of pyroglutamate-3 A β , a commercial ELISA method was used to measure its removal during *ex vivo* phagocytosis. Suspensions that were collected following methods above were thawed on ice, centrifuged 16,000x g 20 min at 4°C before dilution and analysis using a commercial ELISA kit (Amyloid Beta N3pE A β , IBL America). A β _{pE3-42} ELISA assay is highly specific to A β _{pE3-42} when compared to unmodified A β ₁₋₄₂ (data not shown).

[00290] Results are shown in Figure 26A and Figure 26B (data shown in Table 12 and Table 13, respectively), which show levels of pyroglutamate-3 A β in brain sections after treatment with indicated antibodies, h2931 in Figure 26A and h2731 in the Figure 26B, each compared to a healthy control and compared to AD brain treated with IgG1 isotype control. Sections from different AD brains were used for each treatment. h2731 and h2931 both demonstrate highly significant reductions in pyroglutamate-3 A β over isotype control.

[00291] Figure 24 and Figure 26B, taken together, indicate anti-A β antibodies of the present invention (e.g., h2731) promote clearance of both A β ₁₋₄₂ and A β _{pE3-42} protein when incubated on AD patient brain tissue sections with primary mouse microglia. These results confirm that these antibodies clear both A β ₁₋₄₂ and A β _{pE3-42} in the human pathology setting.

[00292] The N-terminal-targeted anti-A β antibodies, facilitated abundant microglia-mediated clearance of A β plaque species, including pyroglutamate-modified A β , in brain tissue from AD patients. These data support further development of antibodies of the present invention as a subcutaneously administered antibody immunotherapy for Alzheimer's disease.

Table 12

Condition	AbpE3-42 (pg/ml)	Stdev
Healthy control	44.20	6.39
AD brain + hIgG1 isotype	259.42	27.39
AD brain + h2931	62.59	16.16

Table 13

Condition	AbpE3-42 (pg/ml)	Stdev
Healthy control	26.75	34.83
AD brain + hIgG1 isotype	478.91	117.80
AD brain + h2731	153.76	67.59

[00293] Example 11. Blocking Oligomers in Hippocampal Binding Assay

[00294] A β Binding Assay in Rat Hippocampal Neurons

[00295] E18 primary rat hippocampal neurons were cultured as described by Zago et al. (J. Neurosci 22 February 2012, 32 (8) 2696-2702). Soluble A β was pre-incubated with and without antibody on culture DIV14-21 to block neuritic binding to primary neurons.

[00296] Fresh unlabeled, biotinylated or (9:1) unlabeled:biotinylated soluble A β was prepared one day prior and incubated overnight at 4 °C. The A β was spun down @ 14,000 RPM for 15 minutes before use.

[00297] Each dilution of A β solution and antibody at (2x) of the final treatment concentration in one-half of final treatment volume using NeuroBasal-no phenol red (NB-NPR) or NbActiv4-NPR medium were prepared. After combining, the mixture was mixed 3-4 times then pre-incubated for 30 minutes at 37°C.

[00298] Immediately before binding assay, the neurons were rinsed with pre-warmed NB-NPR at 150 μ L/well. The buffer was aspirated and then antibody/ A β treatment was added to cells at 60 μ L/well then incubated for 30-40 minutes at 37°C under normal incubator conditions (5% CO₂; 9% O₂).

[00299] The neurons were rinsed twice in 150 μ L/well NB-NPR then fixed in 4% paraformaldehyde in 1x DPBS for 20 minutes at room temperature.

[00300] The cells were permeabilized in 0.1% Triton X-100 in 1x DPBS for 5 minutes and then blocked in 10% normal goat serum (NGS) for 1 hour at room temperature (RT).

[00301] The samples were incubated with microtubule-associated protein 2 (MAP2) and neuronal nuclear protein (NeuN) primary antibodies in 100 μ L/well 1x DPBS containing 1% BSA + 1% NGS overnight at 4°C. On the next day, the samples were rinsed twice in 150 μ L/well 1x DPBS for 5 minutes each wash. Secondary antibody was added for 1 hour @ room temperature in 100 μ L/well 1x DPBS + 1% BSA + 1% NGS.

[00302] High-content imaging (HCI) analysis was performed to quantify soluble A β neuritic binding spots using Operetta HCI CLS instrument (Perkin Elmer; modified Neurite Outgrowth algorithm; 40x H₂O objective; 25-40 fields per well in microplate format; (n=3) per condition. MAP2 and NeuN neuronal markers were used to each trace neurite tree and count cell body number per optical field (e.g., with microtubule-associated protein 2 (Abcam; Cambridge, UK), and NeuN (EMD Millipore) primary antibodies followed by AlexaFluor (Thermo Fisher Scientific) secondary detection antibodies). Neuritic A β spots were detected using various monoclonal and polyclonal A β antibodies (e.g., mouse monoclonal anti-A β antibody MabN254 (EMD Millipore)) followed by AlexaFluor (Thermo Fisher Scientific) secondary detection antibodies or streptavidin-AF488 for biotinylated A β material. Figure 15A and Figure 15B show that increasing concentrations of anti-A β antibody reduces the number of spots per neuron, indicating activity against A β . Figure 23 shows h2731 effectively blocked the binding of soluble A β aggregates to rat hippocampal synapses (A β 42 spots per neuron) in a concentration-dependent manner. The effect of h2731 was detected at molar mAb:A β 42 ratios as low as 1:500 ($p < 0.05$) and reached >90% blockade of binding at 1:50 molar ratios ($p < 0.001$) relative to A β 42 alone (no mAb preincubation). Data shown in Table 14.

Table 14

	Soluble A β	Isotype Control	h2731	h2731	h2731	h2731
	1 μ M	1:50	1:1000	1:500	1:100	1:50
Mean (A β spots per neuron)	76.3	58.7	51.0	39.7	11.3	6.3
SD	28.2	12.9	14.9	12.1	4.9	1.5

[00303] Example 12. Anti-A β antibody binding to native and modified A β species

[00304] Cryostat sections of human AD brain were thaw-mounted onto poly-D-lysine coated coverslips and placed in 24-well tissue culture plates and incubated with test antibodies for 1 hour at 37°C 5% CO₂. Primary mouse microglial cells were then seeded at

800,000 cells/ml, and the cultures were maintained at 37°C 5% CO₂ for 72 hours. Media was carefully aspirated, and sections washed with PBS. The sections were resuspended in 8M urea for quantification by ELISA for A β _{pE3-42} (Immuno-Biological Laboratories, Minneapolis, MN), or MSD for A β ₁₋₄₂ (Meso Scale Diagnostics, Rockland, MD). The Immuno-Biological Laboratories A β _{pE3-42} ELISA kit specifically detects the pE3-42 species with no detectable signal for full-length A β .

[00305] Figure 27 demonstrates that h2731 binds with high apparent affinity to the N-terminus of full length A β but not directly to pyroglutamate-modified A β (A β _{pE3-42}). h2731 bound with a half-maximal effective concentration (EC₅₀) of 8.1 ng/mL (54 pM) to fibrillar A β species with an unmodified N-terminus (A β ₁₋₄₂). h2731 demonstrated no detectable binding to A β _{pE3-42} up to 100ng/ml.

[00306] Example 13. *In vitro* phagocytic-mediated clearance – THP-1 human monocyte-mediated uptake of A β ₁₋₄₂ protofibrils

[00307] Synthetic protofibrils of A β ₁₋₄₂ containing an S26C mutation were generated as described in Paranjape et al., ACS Chem. Neurosci. 2012, 3, 302–311. Briefly, A β peptides were dissolved in 100% hexafluoroisopropanol (HFIP) (SigmaAldrich, St. Louis, MO) at 1 mM, aliquoted into sterile microcentrifuge tubes, and evaporated uncovered at room temperature overnight in a fume hood. The following day, the aliquots were vacuum-centrifuged to remove any residual HFIP and stored in desiccant at –20 °C. Some A β peptides were treated with 100% trifluoroacetic acid and vacuum centrifuged prior to HFIP treatment. A β oligomers and fibrils obtained directly from lyophilized aliquots were prepared by resuspending lyophilized A β peptide aliquots in sterile anhydrous dimethyl sulfoxide (DMSO) (Sigma-Aldrich, St. Louis, MO) at 5 mM. For oligomer preparation the sample was diluted to 100 μ M in sterile ice-cold phenol red-free Ham's F-12 cell culture medium with L-glutamine (F-12, Bioworld, Dublin, OH) and incubated for 24 hours at 4 °C. For fibril preparation, the sample was diluted to 100 μ M in 10 mM HCl and incubated for 24 hours at 37 °C. A β concentrations in these preparations were based on dry peptide weight.

[00308] Mature protofibrils were conjugated to pHrodo Red Maleimide (Thermo Fisher) before use in *in vitro* phagocytic-mediated clearance assays.

[00309] Antibodies at concentrations of 6.25, 3.13, 1.56, 0.78, 0.39, 0.20, 0.098, and 0.049 μ g/ml were preincubated for 30 min at room-temperature with pHrodo-A β ₁₋₄₂ protofibrils,

followed by the addition of THP-1 phagocytic cells. After a 3-hour incubation at 37 °C and 5% CO₂, antibody-mediated phagocytic-mediated clearance was assessed by measuring cellular pHrodo signal via flow cytometry.

[00310] As shown in Figure 28A and Figure 28B, anti-A β antibodies exhibited A β ₁₋₄₂ protofibril phagocytic activity in a concentration-dependent fashion. These results suggest that antibodies of the present invention may be able to drive A β ₁₋₄₂ clearance in brain tissue.

[00311] **Example 14. Distribution of total and pyroglutamate-modified A β in brain tissue from advanced AD patients**

[00312] *Ex vivo* IHC methods as described above and herein were conducted on AD brain tissue to determine the distribution of A β _{1-XX} (detected with an N-terminal anti-A β antibody) and anti-A β _{pE3-42}.

[00313] Evaluation of A β _{1-XX} and A β _{pE3-42} confirmed widespread distribution of both species in tissue from patients with advanced stage AD. The distribution pattern (Figure 29A(1) and Figure 29A(2) (and magnified Figure 29B(1) and Figure 29B(2), respectively)) and quantification (Figure 29C) of the percent area covered by A β _{1-XX} compared to A β _{pE3-42} were consistent with prior studies, suggesting that A β _{pE3-42} represents a relatively smaller pool of modified A β intermingled with the unmodified A β targeted by N-terminal A β antibodies. A β _{pE3-42} is shown in Figure 29A(2) and Figure 29B(2), and intact N-terminal A β is shown in Figure 29A(1) and Figure 29B(1). Anti-A β _{pE3-42} antibody did not cross-react with A β ₁₋₄₂ (data not shown).

[00314] The box in Figure 29A(1) and Figure 29B(1) show an A β plaque with intact N-terminal A β and modified A β _{pE3-42} proximal to blood vessel. Table 15 below reports the quantification of staining in plaques in Figure 29B(1) and Figure 29B(2) that is presented as graph in Figure 29C. The difference between the mean values is statistically significant (p=0.007, paired two-tailed *t*-test).

Table 15

Antibody	% Area Stained (Mean $\pm$ SD; N=5)
anti-N-terminal A β antibody	12.59 $\pm$ 4
anti- A β _{pE3-42} A β antibody	7.17 $\pm$ 1.8

[00315] **Example 15. Anti-A β antibody h2731 Colocalizes with A β _{pE3-42} in AD brain**

[00316] Colocalization of h2731 immunostaining and A β _{pE3-42} was assessed by immunofluorescent microscopy. An N-terminal anti-A β antibody (in this case h2731) was pre-conjugated to a Cy3-secondary anti-human antibody (Jackson Laboratories) before application to tissues. A β _{pE3-42} was detected using a mouse anti-A β _{pE3-42} antibody with a 488-AlexaFluor-conjugated anti-mouse secondary antibody. Slides were imaged using a Metamorph-assisted IX81 Olympus microscope connected to a Hamamatsu camera (C10600-10B).

[00317] Figure 30 (panel A) shows localization of h2731 to A β plaques; Figure 30 (panel B) shows localization of anti-A β _{pE3-42} antibody signal to A β plaques; and Figure 30 (panel C) shows colocalization of h2731 and anti-A β _{pE3-42} antibody signal to A β plaques. Overlapping signal appears more prominent in dense core regions of the plaques.

[00318] Example 16. Anti-A β antibodies of the present invention promote A β _{pE3-42} clearance from AD brain tissue *ex vivo* in a dose-dependent manner with higher efficacy than aducanumab

[00319] Using methods described above and elsewhere herein, the ability of aducanumab and antibodies of the present invention (e.g., h2731) to clear A β _{pE3-42} protein from AD brain tissue was assessed.

[00320] A physiologically relevant dose-response series of h2731 (3 ng/ml, 10 ng/ml, 30 ng/ml and 100 ng/ml) was incubated with AD patient brain tissue sections and primary mouse microglia for 72 hours. h2731 promoted A β _{pE3-42} clearance in a concentration-dependent fashion. Results are presented in Table 16 below and Figure 31A.

Table 16

Antibody	Concentration (ng/ml)	Ave Aβ_{pE3-42} (pg/ml) (n=4)	Stdev
hIgG1 isotype	100	524.34	83.36
h2731	3	479.56	129.92
h2731	10	339.06	165.44
h2731	30	229.28	51.16
h2731	100	261.15	60.81

[00321] h2731 robustly promotes clearance of A β _{pE3-42} from AD patient brain tissue sections by microglial phagocytosis in a concentration-dependent manner and during a relatively short incubation period (72 hours). Thus, the antibodies of the present invention

promote *ex vivo* clearance of A β _{PE3-42} from an AD patient brain at a concentration range expected to be reached with subcutaneous administration.

[00322] Another series of experiments were conducted comparing h2731 at 25 ng/ml and 75 ng/ml to aducanumab at 25 ng/ml and 225 ng/ml. Results are presented in Table 17 and Figure 31B.

Table 17

Antibody	Concentration (ng/ml)	Ave Aβ_{PE3-42} (pg/ml) (n=4)	Stdev
hIgG1 isotype	225	449.11	58.14
Adu	225	227.30	98.95
Adu	25	247.34	48.06
h2731	75	52.83	25.40
h2731	25	71.31	64.93

[00323] h2731 exhibited superior A β _{PE3-42} clearance activity when compared to aducanumab, even at 9-fold lower concentrations.

[00324] Another physiologically relevant dose-response series of h2731 and aducanumab (3 ng/ml, 25 ng/ml, and 225 ng/ml) was incubated with AD patient brain tissue sections and primary mouse microglia for 72 hours, both compared to IgG1 isotype control. While both h2731 and aducanumab promoted A β _{PE3-42} clearance in a concentration-dependent fashion, h2731 again did so significantly more potently, with a p-value of <0.0001 at a 9-fold lower concentration than required for aducanumab to reach a p-value of 0.0005. Results are presented in Table 18 below as well as Figure 32A.

Table 18

Antibody	Concentration (ng/ml)	Aβ_{PE3-42} (pg/ml)	Stdev
hIgG1 isotype	225	1.00	6.73
Adu	225	85.97	74.35
Adu	25	146.70	24.30
Adu	3	245.97	41.70
h2731	225	20.60	14.44
h2731	25	41.07	31.15
h2731	3	154.95	35.89

[00325] In order to verify that h2731-mediated *ex vivo* phagocytosis activity is microglia dependent, a +/- microglia experiment was performed. While microglia alone drive some

A β _{pE3-42} clearance from AD patient tissue sections, clearance is significantly more robust with the combination of h2731 and microglia. h2731 appears to require the presence of microglia for clearance activity, as h2731 alone has shows no activity without microglia. Results are presented in Table 19 and Figure 32B.

Table 19

Antibody	Concentration (ng/ml)	Aβ_{pE3-42} (pg/ml)	Stdev
hIgG1 isotype	75	271.79	27.01
h2731	75	263.70	51.28
hIgG1 + Microglia	75	174.58	15.75
h2731 + Microglia	75	58.37	15.53

[00326] The tested antibody concentrations were based on CNS ranges estimated at 0.1% of steady-state plasma minimum and maximum concentrations from modeled pharmacokinetics following monthly administration of 3mg/kg subcutaneous h2731 (25-75 ng/ml) or 10 mg/kg of intravenous aducanumab (25-225 ng/ml) in humans (Figure 33).

[00327] Antibodies of the present invention promote ex vivo clearance of A β _{pE3-42} from an AD patient brain at a concentration range expected to be reached with subcutaneous administration and with greater biological activity than aducanumab.

[00328] Antibody h2731 reduces A β _{pE3-42} staining in AD brain. FIG 34 shows that A β _{pE3-42} (staining indicated by white arrows) was observed in plaques (white triangles) and associated with blood vessels (circular shape in Figure 34A and Figure 34C) in AD brain treated with human IgG isotype control antibody (Figure 34A and Figure 34B). Treatment with h2731 enhanced microglia-mediated reduction of A β _{pE3-42} levels as evidenced by the reduction in plaques (Figure 34C and Figure 34D). Antibodies of the present invention, as exemplified by h2731, reduce plaques containing A β _{pE3-42} in tissue.

[00329] Example 17. h2731 target engagement

[00330] Female APPxPS1 mice expressing a mutant human amyloid precursor protein (hAPP[V717I]) and a mutant human presenilin 1 (hPS1[A246E]) were used to evaluate the ability of h2731 and aducanumab to traverse the blood-brain-barrier subsequent to peripheral administration and bind to amyloid-beta (A β) plaques in the brain. The average age of the animals at the start of the study was 6.7 months. One day prior to drug administration all animals received an injection of an anti-CD4 antibody (20 mg/kg, intravenous) to prevent the

formation of anti-drug antibodies in mice receiving h2731 or aducanumab, both of which are fully humanized antibodies. h2731 (3 or 10 mg/kg, subcutaneous, SC) or aducanumab (10 mg/kg, intravenous) were dosed weekly for three weeks and animals were euthanized one week later. Following transcardial perfusion with ice-cold saline, brains were extracted from the mice and flash frozen in 2-methylbutane on dry ice and stored at -80 °C.

[00331] Serial sagittal 10 µm thick cryosections were generated using a Leica 3050S cryostat. The sections were directly thaw-mounted on positively charged glass slides and were stored at -20 °C until use. Prior to IHC, the slides were immersed in 10% neutral buffered formalin solution for 10 minutes at 4 °C, rinsed in PBS, then incubated for an hour at 37 °C in a glucose oxidase solution (20 mM beta D(+) glucose, 2 mM sodium azide, and 2 units/mL glucose oxidase in 1X PBS). The slides were rinsed 3 times for 5 minutes in PBS before they were transferred onto staining racks for processing in an automated stainer. A biotin-SP-conjugated goat anti human IgG (H+L) (Jackson ImmunoResearch Laboratories #109-065-088) was used to detect h2731 or aducanumab in APPxPS1 brain tissue. The staining was performed in an automated Leica Bond Rx Stainer (Leica Biosystems), using the Bond Research Kit (DS980, Leica Biosystems). Hematoxylin counter-staining of nuclei was subsequently applied to sections before dehydration in an ascending series of alcohols, clearing in xylene, cover-slipping, and air-drying. The whole sections were imaged using a NanoZoomer 2.0HT slide scanner (Hamamatsu Corporation, Japan). Morphometric analysis of the digitalized images was carried out using Halo software (V2.1.1537). After delineation of the cerebral cortex as region of interest, the percent of stained tissue area was determined. Data are presented in Table 20.

Table 20

	h2731		Aducanumab
	3 mg/kg, SC	10 mg/kg, SC	10 mg/kg, IV
Plaque Binding (% ROI)	0.070 ± 0.025	0.079 ± 0.034	0.060 ± 0.034

ROI = region of analysis. All data represent mean ± SD of n = 5 animals per group

[00332] Reduction in numbers or size of Aβ plaques in Alzheimer's Disease may correlate with slowing or reversing of disease progression. The ability of the anti-Aβ antibodies of the present invention to bind to and clear Aβ in vivo following peripheral administration supports the potential utility of these antibodies as therapeutic agents.

[00333] Thus, the antibodies of the present invention promote microglia-mediated clearance of A β ₁₋₄₂ in brain tissue from patients with AD. Although antibodies of the present invention may not target the pyroglutamate modification directly, they may effectively clear A β _{PE3-42} at concentrations predicted to be clinically relevant and with higher potency and greater biologic activity than aducanumab, as exemplified by h2731. Clearance of pyroglutamate species by these antibodies may be due to the ability of microglia to recognize opsonized plaques and engulf large particles with diverse content. The antibodies of the present invention may therefore clear other neurotoxic elements co-deposited in plaques by this same mechanism.

[00334] All publications (including GenBank Accession numbers, UniProtKB/Swiss-Prot accession numbers and the like), patents and patent applications cited are herein incorporated by reference in their entirety for all purposes to the same extent as if each individual publication, patent and patent application was specifically and individually indicated to be incorporated by reference in its entirety for all purposes. In the event of any variance in sequences associated with Genbank and UniProtKB/Swiss-Prot accession numbers and the like, the application refers to the sequences associated with the cited accession numbers as of the effective filing date of the application meaning the actual filing date or earlier date of a priority application disclosing the relevant accession number. Any feature, step, element, embodiment, or aspect of the disclosure can be used in combination with any other unless specifically indicated otherwise. Although the present disclosure has been described in some detail by way of illustration and example for purposes of clarity and understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. An antibody or fragment thereof that specifically binds to A β peptide, comprising a heavy chain variable region comprising heavy chain CDR1, CDR2 and CDR3 and a light chain variable region comprising light chain CDR1, CDR2 and CDR3, wherein the heavy chain CDR1, CDR2 and CDR3 and the light chain CDR1, CDR2 and CDR3 are as shown for one of the antibodies in Table 1A and Table 1B.
2. The antibody or fragment thereof of claim 1, wherein the heavy chain variable region is as shown for one of the antibodies in Table 1A and Table 1B.
3. The antibody or fragment thereof of claim 1, wherein the light chain variable region is as shown for one of the antibodies in Table 1A and Table 1B.
4. An antibody or fragment thereof that specifically binds to A β peptide, comprising a heavy chain variable region comprising heavy chain CDR1, CDR2 and CDR3 and a light chain variable region comprising light chain CDR1, CDR2 and CDR3, wherein
 - heavy chain CDR1 comprises one of SEQ ID NO: 16, 19, or 20,
 - heavy chain CDR2 comprises one of SEQ ID NO: 20, 21, 22 or 23,
 - heavy chain CDR3 comprises one of SEQ ID NO: 18, 24, or 25,,
 - light chain CDR1 comprises one of SEQ ID NO: 26, 29, 31, or 32,
 - light chain CDR2 comprises one of SEQ ID NO: 33, 34, 35 or 36, and
 - light chain CDR3 comprises one of SEQ ID NO: 28, 38 or 39.
5. The antibody or fragment thereof of claim 1 or claim 4, wherein the heavy chain variable region, excluding the CDRs, is at least 95% identical an amino acid sequence selected from SEQ ID NO: 3, 4, 5, 6, and 7, and the light chain variable region, excluding the CDRs, is at least 95% identical an amino acid sequence selected from SEQ ID NO: 8, 9, 10, 11, 12, 13, 14, and 15.
6. The antibody or fragment thereof of claim 5, wherein heavy chain variable region, excluding the CDRs is at least 98% identical to an amino acid sequence selected from SEQ ID NOs: 3, 4, 5, 6, and 7, and the light chain variable region, excluding the CDRs, is at least 98% identical to an amino acid sequence selected from SEQ ID NO: 8, 9, 10, 11, 12, 13, 14 and 15.

7. The antibody or fragment thereof of claim 6, wherein heavy chain variable region is selected from SEQ ID NOs: 3, 4, 5, 6, and 7, and the light chain variable region is selected from SEQ ID NO: 8, 9, 10, 11, 12, 13, 14 and 15.
8. An antibody or fragment thereof that specifically binds to A β peptide, comprising a heavy chain variable region comprising heavy chain CDR1, CDR2 and CDR3 and a light chain variable region comprising light chain CDR1, CDR2 and CDR3, wherein:
- heavy chain CDR1 comprises amino acid sequence GFTFSNX₁GMS, wherein X₁ is Y or F (SEQ ID NO: 88);
 - heavy chain CDR2 comprises amino acid sequence SX₁RSGSGRTYYSDNVKG, wherein X₁ is I or V (SEQ ID NO: 89);
 - heavy chain CDR3 comprises amino acid sequence YDHYX₁GX₂SDY, wherein X₁ is S or T and X₂ is S or T (SEQ ID NO: 90);
 - light chain CDR1 comprises amino acid sequence KSSQSLLDYDGKTYLN (SEQ ID NO: 91);
 - light chain CDR2 comprises amino acid sequence X₁VX₂NRDX₃, wherein X₁ = K or R, X₂ is S or T, and X₃ is S or T (SEQ ID NO: 92);
 - light chain CDR3 comprises amino acid sequence WQGTHFPRX₁, wherein X₁ is S or T (SEQ ID NO: 93).
9. The antibody or fragment thereof of claim 8, wherein light chain CDR3 comprises WQGTHFPRX₁FX₂, wherein X₁ is S or T and X₂ is F or Y (SEQ ID NO: 94).
10. An antibody or fragment thereof that specifically binds to A β peptide, comprising a heavy chain variable region comprising heavy chain CDR1, CDR2 and CDR3 and a light chain variable region comprising light chain CDR1, CDR2 and CDR3, wherein:
- heavy chain CDR1 comprises amino acid sequence GFTFX₁NX₂GMS, wherein X₁ is S or A, and X₂ is Y or F (SEQ ID NO: 95);
 - heavy chain CDR2 comprises amino acid sequence SX₁RSGX₂X₃RTYYSDNVKG, wherein X₁ is I or V, X₂ is S or G and X₃ is S or G (SEQ ID NO: 96);
 - heavy chain CDR3 comprises amino acid sequence YDHYX₁GX₂SDY, wherein X₁ is S or T and X₂ is S or T (SEQ ID NO: 90);

light chain CDR1 comprises amino acid sequence $X_1SSQSLX_2DX_3DGKTYLN$, wherein X_1 is K or R, X_2 is V, M or L, and X_3 is Y, T or S (SEQ ID NO: 97);

light chain CDR2 comprises amino acid sequence $X_1VX_2NRX_3X_4$, wherein X_1 = K or R, X_2 is S or T, and X_3 is E or D, and X_4 is S or T (SEQ ID NO: 98).

light chain CDR3 comprises amino acid sequence $WQGX_1HFPRX_2$, wherein X_1 is S or T, and X_2 is S or T (SEQ ID NO: 99).

11. The antibody or fragment thereof of claim 10, wherein light chain CDR3 comprises $WQGTHFPRX_1FX_2X_3$, wherein X_1 is S or T, X_2 is S or T and X_3 is F or Y (SEQ ID NO: 100).
12. The antibody or fragment thereof of one of claims 1 - 11, wherein the antibody is humanized.
13. The antibody or fragment thereof of one of claims 1 - 11 where the antibody is human IgG1.
14. The antibody or fragment thereof of one of claims 1 to 11, wherein the antibody is a full antibody, a chimeric antibody, a CDR-grafted antibody, or a recombinant antibody.
15. The antibody or fragment thereof of one of claims 1 to 11 wherein the fragment is a Fab, Fab', F(ab')₂, Fabc, or Fv.
16. The antibody or fragment thereof of one of claims 1 to 11, further comprising heavy chain constant region comprising an amino acid sequence at least 95% identical to SEQ ID NO:40.
17. The antibody or fragment thereof of one of claims 1 to 11, further comprising light chain constant region comprising an amino acid sequence at least 95% identical to SEQ ID NO:41.
18. The antibody or fragment thereof of one of claims 1 to 17, wherein the antibody specifically binds to an epitope having an amino acid sequence including three or more amino acid positions from amino acids 1-7 of A β .
19. A nucleic acid encoding the heavy chain and/or light chain of an antibody or fragment as described in any one of claims 1 to 18.

20. A pharmaceutical composition comprising the antibody or fragment thereof of one of claims 1 to 19 and pharmaceutically acceptable carrier or diluent.
21. A method of producing the antibody or fragment thereof of one of claims 1 to 18, the method comprising:
- (a) culturing cells transformed with nucleic acids encoding the heavy and light chains of the antibody or fragment thereof, so that the cells secrete the antibody or fragment thereof; and
 - (b) purifying the antibody or fragment thereof from cell culture.
22. A method of producing a cell line producing the antibody or fragment thereof of one of claims 1 to 18, the method comprising:
- (a) introducing a vector encoding heavy and light chains of the antibody or fragment thereof and a selectable marker into cells;
 - (b) propagating the cells under conditions to select for cells having increased copy number of the vector;
 - (c) isolating single cells from the selected cells; and
 - (d) banking cells cloned from a single cell selected based on yield of antibody or a fragment thereof.
23. The method of claim 22 further comprising propagating the cells under selective conditions and screening for cell lines naturally expressing and secreting at least 100 mg/L/10⁶ cells/24 h.
24. A method of preventing or treating amyloidogenic disease in a patient, comprising administering an effective dosage of the antibody or fragment of one of claims 1 to 18 to the patient.
25. The method of claim 24, wherein the amyloidogenic disease is systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.
26. A method of treating a patient diagnosed with Alzheimer's disease, the method comprising administering to a patient having the disease the antibody or fragment thereof of one of claims 1 to 18, in a regime effective to treat the disease.

27. A method of reducing the risk or delaying the outset of Alzheimer's disease in a patient whose risk of the disease has been determined from a genetic or biochemical marker, comprising administering to a patient an antibody or fragment thereof of one of claims 1 to 18, in a regime effective to reduce the risk or delay the outset of the disease.
28. A method for effecting improvement of cognition in a subject having a condition or disease related amyloidogenic disease, comprising administering to the subject an effective amount of the antibody or fragment thereof of one of claims 1 to 18.
29. The method of claim 28, wherein the amyloidogenic disease is systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.
30. A method of treating Down's syndrome or clinical or pre-clinical Alzheimer's disease in a human subject, comprising administering to the human subject an effective amount of the antibody or fragment of one of claims 1 to 18.
31. A method to inhibit the formation of amyloid plaque in a human subject, comprising administering to the human subject an effective amount of the antibody or fragment of one of claims 1 to 18.
32. A method to reduce amyloid plaque in the brain of a human subject, comprising administering to the human subject an effective amount of a humanized antibody or fragment of one of claims 1 to 18.
33. A method of inhibiting or reducing amyloid plaque in a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the antibody of any one of claims 1 to 18, thereby inhibiting or reducing amyloid plaque in the subject.
34. The method of any one of claims 31 to 33, wherein the amyloid plaque comprises A β ₁₋₄₂, pyroglutamate species of A β (e.g., A β _{pE3-42}), or a combination thereof.
35. A method of detecting amyloid plaques in a subject having or at risk of an amyloidogenic disease, comprising administering to a subject an antibody or fragment thereof of any one of claims 1 to 18, and detecting the antibody or fragment thereof bound to A β in the subject.

36. The method of claim 35, wherein the amyloidogenic disease is systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.
37. The method of claim 35, wherein the antibody or fragment thereof is labeled.
38. The method of claim 35, wherein the antibody or fragment thereof is labeled with a fluorescent label, a paramagnetic label, or a radioactive label.
39. The method of claim 38, wherein the radioactive label is detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).
40. A method of measuring efficacy of treatment in a subject being treated for an amyloidogenic disease, comprising:
- (a) measuring a first level of amyloid plaque in the subject prior to treatment by administering to a subject an antibody or fragment thereof of any one of claims 1-18, and detecting a first amount of the antibody or fragment thereof bound to A β in the subject,
 - (b) administering the treatment to the subject,
 - (c) measuring a second level of amyloid plaque in the subject after treatment by administering to a subject the antibody or fragment thereof, and detecting the antibody or fragment thereof bound to A β in the subject,
- wherein a decrease in the level of amyloid plaque indicates a positive response to treatment.
41. A method of measuring efficacy of treatment in a subject being treated for an amyloidogenic disease, comprising:
- (a) measuring a first level of amyloid plaque in the subject prior to treatment by administering to a subject an antibody or fragment thereof of any one of claims 1-18, and detecting a first amount of antibody or fragment thereof bound to A β in the subject,
 - (b) administering the treatment to the subject,
 - (c) measuring a second level of amyloid plaque in the subject after treatment by administering to a subject the antibody or fragment thereof, and detecting a second amount of antibody or fragment thereof bound to A β in the subject,
- wherein no change in the level of amyloid plaque or a small increase in amyloid plaque indicates a positive response to treatment.

42. A method of promoting clearance of A β in a human subject, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18.
43. The method of claim 42, wherein the A β is present in the subject's brain tissue.
44. A method of clearing A β in a human subject, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18.
45. The method of claim 44, wherein the A β is present in the subject's brain tissue.
46. A method of reducing A β in a human subject, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18.
47. The method of claim 46, wherein the A β is present in the subject's brain tissue.
48. A method of reducing A β accumulation or aggregation in a human subject, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18.
49. The method of claim 48, wherein the A β is present in the subject's brain tissue.
50. A method of inhibiting A β accumulation or aggregation in a human subject, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18.
51. The method of claim 50, wherein the A β is present in the subject's brain tissue.
52. A method of promoting clearance of A β in brain tissue of a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18, thereby promoting clearance of A β in brain tissue in the subject.
53. A method of clearing A β in brain tissue of a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18, thereby clearing A β in brain tissue in the subject.
54. A method of reducing A β in brain tissue of a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the

antibody or fragment of any one of claims 1 to 18, thereby reducing A β in brain tissue in the subject.

55. A method of reducing A β accumulation or aggregation in brain tissue of a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18, thereby reducing A β accumulation or aggregation in brain tissue in the subject.

56. A method of inhibiting A β accumulation or aggregation in brain tissue of a subject having or at risk of developing an amyloidogenic disease, comprising administering to the subject an effective regime of the antibody or fragment of any one of claims 1 to 18, thereby inhibiting A β accumulation or aggregation in brain tissue in the subject.

57. The method of any one of claims 52 to 56 wherein the amyloidogenic disease is systemic amyloidosis, Alzheimer's disease, mature onset diabetes, Parkinson's disease, Huntington's disease, fronto-temporal dementia, Down's syndrome, or mild cognitive impairment.

58. The method of any one of claims 42 to 57, wherein the A β comprises A β ₁₋₄₂, pyroglutamate species of A β (e.g., A β _{pE3-42}), or a combination thereof.

59. The method of any one of claims 24-58, wherein the antibody or fragment is administered by peripheral administration.

60. The method of claim 59, wherein the peripheral administration is intravenous or subcutaneous.