ANTIBODIES RECOGNIZING TAU

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to US Application 62/758,421 filed November 9, 2018 and to PCT application PCT/US2018/059895 filed November 8, 2018, each of which is incorporated by reference in its entirety for all purposes.

REFERENCE TO A SEQUENCE LISTING

[0002] This application includes an electronic sequence listing in a file named 2019-11-08 536322WO_ST25.TXT, created on 08 November 2019 and containing 96,408 bytes, which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

[0003] Tau is a well-known human protein that can exist in phosphorylated forms (see, *e.g.*, Goedert, Proc. Natl. Acad. Sci. U.S.A. 85:4051-4055(1988); Goedert, EMBO J. 8:393-399(1989); Lee, Neuron 2:1615-1624(1989); Goedert, Neuron 3:519-526(1989); Andreadis, Biochemistry 31:10626-10633(1992). Tau has been reported to have a role in stabilizing microtubules, particularly in the central nervous system. Total tau (t-tau, *i.e.*, phosphorylated and unphosphorylated forms) and phospho-tau (p-tau, *i.e.*, phosphorylated tau) are released by the brain in response to neuronal injury and neurodegeneration and have been reported to occur at increased levels in the CSF of Alzheimer's patients relative to the general population (Jack et al., Lancet Neurol 9: 119–28 (2010)).

[0004] Tau is the principal constituent of neurofibrillary tangles, which together with plaques are a hallmark characteristic of Alzheimer's disease. The tangles constitute abnormal fibrils measuring 10 nm in diameter occurring in pairs wound in a helical fashion with a regular periodicity of 80 nm. The tau within neurofibrillary tangles is abnormally phosphorylated (hyperphosphorylated) with phosphate groups attached to specific sites on the molecule. Severe involvement of neurofibrillary tangles is seen in the layer II neurons of the entorhinal cortex, the

CA1 and subicular regions of the hippocampus, the amygdala, and the deeper layers (layers III, V, and superficial VI) of the neocortex in Alzheimer's disease. Hyperphosphorylated tau has also been reported to interfere with microtubule assembly, which may promote neuronal network breakdown.

[0005] Tau inclusions are part of the defining neurophathology of several neurodegenerative diseases including Alzheimer's disease, frontotemporal lobar degeneration, progressive supranuclear palsy and Pick's disease.

BRIEF SUMMARY OF THE CLAIMED INVENTION

[0006] In one aspect, the invention provides an antibody specifically binding to human tau, comprising a mature heavy chain variable region comprising CDRs H1, H2 and H3 comprising SEQ ID NOS:8, 9, and 10, respectively except that position H28 can be occupied by N or T, H54 can be occupied by N or D, H56 can be occupied by D or E, and position H58 occupied by V or I, and a mature light chain variable region comprising CDRs L1, L2 and L3 comprising SEQ ID NOS:12, 13, and 14 respectively, except that position L24 can be occupied by K or R, wherein at least one of the following positions is occupied by the amino acid as specified: H1 is occupied by Q, H5 is occupied by Q, H11 is occupied by L, H20 is occupied by L, H23 is occupied by T, H38 is occupied by K, H75 is occupied by S, H56 is occupied by E, H58 is occupied by I, L10 is occupied by T, L17 is occupied by E, L24 is occupied by R, L37 is occupied by Q, L83 is occupied by L, L86 is occupied by H, L100 is occupied by A or Q, L106 is occupied by L.

[0007] In some such antibodies, CDR-H1 comprises SEQ ID NO:8 or SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:9, SEQ ID NO:87, SEQ ID NO:88, or SEQ ID NO:92, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14. In some such antibodies, CDR-H1 comprises SEQ ID NO:8 or SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:9, SEQ ID NO:87, or SEQ ID NO:88, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14. In some such antibodies, CDR-H1 comprises SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:92, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14.

[0008] In some such antibodies, CDR-H1 has an amino acid sequence comprising SEQ ID NO:86. In some such antibodies, CDR-H2 has an amino acid sequence comprising SEQ ID NO:87. In some such antibodies, CDR-H2 has an amino acid sequence comprising SEQ ID NO:88. In some such antibodies, CDR-H2 has an amino acid sequence comprising SEQ ID NO:92. In some such antibodies, CDR-L1 has an amino acid sequence comprising SEQ ID NO:89.

[0009] In some such antibodies, CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:87. In some such antibodies, CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:88. In some such antibodies, CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:92.

[0010] In some such antibodies, the antibody is a humanized antibody, veneered antibody, or chimeric antibody.

[0011] In some antibodies, the humanized mature heavy chain variable region having an amino acid sequence at least 95% identical to any one of SEQ ID NOs:76-80 and SEQ ID NOs:90-91 and the humanized mature light chain variable region has an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85. In some antibodies, the humanized mature heavy chain variable region has an amino acid sequence at least 95% identical to any one of SEQ ID NOs:76-80 and the humanized mature light chain variable region has an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85. In some antibodies, the humanized mature heavy chain variable region has an amino acid sequence at least 95% identical to any one of SEQ ID NOs:90-91 and the humanized mature light chain variable region has an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85.

[0012] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H93 is occupied by S and H94 is occupied by T. In some such antibodies, positions H93 and H94 are occupied by S and T, respectively.

[0013] In some such antibodies, position H91 in the VH region is occupied by F.

[0014] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by E, H5 is occupied by V, H11 is occupied by V, H20 is occupied I, H23 is occupied by K, H38 is occupied by R, H42 is occupied by G, H43 is occupied by K, H66 is occupied by R, H75 is occupied by T, H76 is occupied by D, H81 is occupied by E, H108 is occupied by L, H109 is occupied by V. In some antibodies, positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, L, and V, respectively.

[0015] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H17 is occupied by T, H80 is occupied by M, H83 is occupied by R. In some antibodies, positions H17, H80, and H83 in the VH region are occupied by T, M, and R, respectively.

[0016] In some such antibodies, position H58 in the VH region is occupied by I.

[0017] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H28 is occupied by T, H67 is occupied by V. In some antibodies, positions H28 and H67 in the VH region are occupied by T and V, respectively.

[0018] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H54 is occupied by D, H56 is occupied by E. In some antibodies, positions H54 and H56 in the VH region are occupied by D and E, respectively.

[0019] In some such antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by Q or E, H5 is occupied by Q or V, H11 is occupied by L or V , H17 is occupied by S or T, H20 is occupied by L or I, H23 is occupied by T or K, H28 is occupied by N or T, H38 is occupied by K or R, H42 is occupied by

E or G, H43 is occupied by Q or K, H54 is occupied by N or D, H56 is occupied by D or E, H58 is occupied by V or I, H66 is occupied by K or R, H67 is occupied by A or V, H75 is occupied by S or T, H76 is occupied by N or D, H80 is occupied by L or M, H81 is occupied by Q or E, H83 is occupied by T or R , H91 is occupied by F or Y, H93 is occupied by S, H94 is occupied by T, H108 is occupied by T or L, H109 is occupied by L or V.

[0020] In some antibodies, positions H91, H93, and H94 in the VH region are occupied by F, S, and T, respectively. In some antibodies, positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, F, S, T,L, and V, respectively. In some antibodies, positions H1, H5, H11, H17, H20, H23, H38, H42, H43, H58, H66, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T,I, K, R, G, K, I, R, T, D, M, E, R, S, T, L, and V, respectively. In some antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, I, R, V, T, D, M, E, R, S, T, L, and V, respectively. In some antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, I, R, V, T, D, M, E, R, S, T, L, and V, respectively. In some antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, F, S, T, L, and V, respectively. In some antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, S, T, L, and V, respectively.

[0021] In some such antibodies, at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is occupied by S, L10 is occupied by S, L15 is occupied by L, L83 is occupied by V, L86 is occupied by Y, and L106 is occupied by I. In some antibodies, positions L7, L10, L15, L83, L86, and L106 are occupied by S, S, L, V, Y, and Y, respectively.

[0022] In some such antibodies, at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is T or S, L10 is T or S, L15 is I or L, L17 is Q or E, L24 is K or R, L37 is L or Q, L45 is K or R, L83 is L or V, L86 is H or Y, L100 is A or Q, L106 is L or I.

[0023] In some antibodies, positions L7, L10, L15, L83, L86, and L106 in the VL region are occupied by S, S, L, V, Y, and I, respectively. In some antibodies, positions L7, L10, L15, L17, L24, L37, L45, L83, L86, L100, and L106 in the VL region are occupied by S, S, L, E, R, Q, R, V, Y, Q, and I, respectively.

[0024] In some antibodies, the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:76-80 and SEQ ID NOs:90-91 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85. In some antibodies, the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:76-80 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85. In some antibodies, the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:90-91 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85.

[0025] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0026] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an

amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0027] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0028] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0029] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, he mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0030] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an

amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0031] In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84. In some antibodies, the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

[0032] For example, the antibody can be a chimeric antibody. For example, the antibody can be a veneered antibody.

[0033] The antibody can be an intact mouse, chimeric, veneered or humanized antibody or a binding fragment, single-chain antibody Fab fragment, Fab'2 fragment, or single chain Fv. Some of the antibodies have a human IgG1 isotype, while others may have a human IgG2 or IgG4 isotype. Some antibodies have the mature light chain variable region fused to a light chain constant region and the mature heavy chain variable region fused to a heavy chain constant region. The heavy chain constant region of some antibodies is a mutant form of a natural human heavy chain constant region which has reduced binding to a Fcγ receptor relative to the natural human heavy chain constant region. In some antibodies, the mature heavy chain variable region is fused to a heavy chain constant region having the sequence of SEQ ID NO:103 with or without the C-terminal lysine and/or the mature light chain variable region is fused to a light chain constant region having the sequence of SEQ ID NO:104.

[0034] Some antibodies may have at least one mutation in the constant region, such as a mutation that reduces complement fixation or activation by the constant region, for example, a mutation at one or more of positions 241, 264, 265, 270, 296, 297, 318, 320, 322, 329 and 331 by EU numbering. Some antibodies have an alanine at positions 318, 320 and 322. Some antibodies can be at least 95% w/w pure. The antibody can be conjugated to a therapeutic, cytotoxic, cytostatic, neurotrophic, or neuroprotective agent.

[0035] In another aspect, the invention provides a pharmaceutical composition comprising any of the antibodies disclosed herein and a pharmaceutically-acceptable carrier.

[0036] In another aspect, the invention provides a nucleic acid encoding the heavy chain and/or light chain of any of the antibodies disclosed herein, a recombinant expression vector comprising the nucleic acid and a host cell transformed with the recombinant expression vector. For example, the nucleic acid can have a sequence comprising any one of SEQ ID NOs:30-31, 93-99, 100-102, and 105-106. In another example, the nucleic acid can have a sequence comprising any one of SEQ ID NOs:30-31, 93-97, 100-102, and 105-106. In another example, the nucleic acid can have a sequence comprising any one of SEQ ID NOs:30-31, 98-99, 100-102, and 105-106.

[0037] In another aspect, the invention provides a vector comprising a nucleic acid encoding a mature heavy chain variable region and a mature light chain variable region operably linked to one or more regulatory sequences to effect expression in a mammalian cell of any of the antibodies disclosed herein, a host cell comprising the nucleic acid, and a method of expressing an antibody in a mammalian cell comprising incorporating the nucleic acid into the genome of a transgenic animal, whereby the antibody is expressed.

[0038] Some vectors comprise a nucleic acid further encoding a heavy chain constant region fused to the mature heavy chain variable region and a light chain constant region fused to the mature light chain variable region. In some vectors, the encoded heavy chain constant region has the sequence of SEQ ID NO:103 with or without the C-terminal lysine and the encoded light chain constant region has the sequence of SEQ ID NO:104. In some vectors, the heavy chain constant region is encoded by the sequence of SEQ ID NO:105 and the light chain constant region is encoded by the sequence of SEQ ID NO:106.

[0039] In some vectors, the expressed antibody encoded by the nucleic acid is a scFv. In some vectors, the expressed antibody encoded by the nucleic acid is a Fab fragment.

[0040] In some vectors, the one or more regulatory sequences include one or more of a promoter, enhancer, ribosome binding site, and transcription termination signal. In some vectors, the nucleic acid further encodes signal peptides fused to the mature heavy and light chain variable regions. In some vectors, the nucleic acid is codon-optimized for expression in a

host cell. In some vectors, the one or more regulatory sequences include a eukaryotic promoter. In some vectors, the nucleic acid further encodes a selectable gene.

[0041] In another aspect, the invention provides first and second vectors respectively comprising nucleic acids encoding a mature heavy chain variable region and a mature light chain variable region, each operably linked to one or more regulatory sequences to effect expression in a mammalian cell of any of the antibodies disclosed herein, a host cell comprising the nucleic acids, and a method of expressing an antibody in a mammalian cell comprising incorporating the nucleic acids into the genome of a transgenic animal, whereby the antibody is expressed.

[0042] In some vectors, the nucleic acids respectively further encode a heavy chain constant region fused to the mature heavy chain variable region and a light chain constant region fused to the mature light chain variable region. In some vectors, the encoded heavy chain constant region has the sequence of SEQ ID NO:103 with or without the C-terminal lysine and the encoded light chain constant region has the sequence of SEQ ID NO:104. In some vectors, the heavy chain constant region is encoded by the sequence of SEQ ID NO:105 and the light chain constant region is encoded by the sequence of SEQ ID NO:106.

[0043] In yet another aspect, the invention provides methods of humanizing any non-human antibody described herein, for example, mouse antibody 3D6, wherein 3D6 is characterized by a mature heavy chain variable region of SEQ ID NO:7 and a mature light chain variable region of SEQ ID NO:11. Such methods can involve selecting one or more acceptor antibodies, synthesizing a nucleic acid encoding a humanized heavy chain comprising CDRs of the mouse heavy chain and a nucleic acid encoding a humanized light chain comprising CDRs of the mouse antibody light chain, and expressing the nucleic acids in a host cell to produce a humanized antibody.

[0044] Methods of producing antibodies, such as a humanized, chimeric or veneered antibody, for example humanized, chimeric or veneered forms of 3D6, are also provided. In such methods, cells transformed with nucleic acids encoding the heavy and light chains of the antibody are cultured so that the cells secrete the antibody. The antibody can then be purified from the cell culture media.

[0045] Cell lines producing any of the antibodies disclosed herein can be produced by introducing a vector encoding heavy and light chains of the antibody and a selectable marker into cells, propagating the cells under conditions to select for cells having increased copy number of the vector, isolating single cells from the selected cells; and banking cells cloned from a single cell selected based on yield of antibody.

[0046] Some cells can be propagated under selective conditions and screened for cell lines naturally expressing and secreting the antibody in an amount of at least 100 mg/L/10^6 cells/24 hours. Single cells can be isolated from the selected cells. Cells cloned from a single cell can then be banked. Single cells can be selected based on desirable properties, such as the yield of the antibody. Exemplary cell lines are cell lines expressing 3D6.

[0047] The invention also provides methods of inhibiting or reducing aggregation of tau in a subject having or at risk of developing a tau-mediated amyloidosis, comprising administering to the subject an effective regime of an antibody disclosed herein, thereby inhibiting or reducing aggregation of tau in the subject. Exemplary antibodies include humanized versions of 3D6.

[0048] Also provided are methods of treating or effecting prophylaxis of a tau-related disease in a subject, comprising administering an effective regime of an antibody disclosed herein and thereby treating or effecting prophylaxis of the disease. Examples of such a disease are Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP). In some methods, the tau-related disease is Alzheimer's disease. In some methods the patient is an ApoE4 carrier.

[0049] Also provided are methods of reducing aberrant transmission of tau comprising administering an effective regime of an antibody disclosed herein and thereby reducing transmission of tau.

[0050] Also provided are methods of inducing phagocytosis of tau comprising administering an effective regime of an antibody disclosed herein and thereby inducing phagocytosis of tau.

[0051] Also provided are methods of inhibiting tau aggregation or deposition comprising administering an effective regime of an antibody disclosed herein thereby inhibiting tau aggregation or deposition.

[0052] Also provided are methods of inhibiting formation of tau tangles comprising administering an effective regime of an antibody disclosed herein.

[0053] The invention also provides a method of detecting tau protein deposits in a subject having or at risk of a disease associated with tau aggregation or deposition comprising administering to a subject an antibody disclosed herein, and detecting the antibody bound to tau in the subject. Examples of such a disease are Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP). In some embodiments, the antibody is administered by intravenous injection into the body of the subject. In some embodiments, the antibody is administered directly to the brain of the subject by intracranial injection or by drilling a hole through the skull of the subject. In some embodiments, the antibody is labeled. In some embodiments, the antibody is labeled with a fluorescent label, a paramagnetic label, or a radioactive label. In some embodiments, the radioactive label is detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).

[0054] The invention also provides a method of measuring efficacy of treatment in a subject being treated for a disease associated with tau aggregation or deposition, comprising measuring a first level of tau protein deposits in the subject prior to treatment by administering to a subject an antibody disclosed herein, and detecting a first amount of the antibody bound to tau in the subject, administering the treatment to the subject, measuring a second level of tau protein

deposits in the in subject after treatment by administering to a subject the antibody, and detecting the antibody bound to tau in the subject, wherein a decrease in the level of tau protein deposits indicates a positive response to treatment.

[0055] The invention also provides a method of measuring efficacy of treatment in a subject being treated for a disease associated with tau aggregation or deposition, comprising measuring a first level of tau protein deposits in the subject prior to treatment by administering to a subject an antibody disclosed herein, and detecting a first amount of antibody bound to tau in the subject, administering the treatment to the subject, measuring a second level of tau protein deposits in the in subject after treatment by administering to a subject the antibody, and detecting a second amount of antibody bound to tau in the subject, wherein no change in the level of tau protein deposits or a small increase in tau protein deposits indicates a positive response to treatment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0056] Figure 1 depicts an alignment of heavy chain variable regions of the mouse 3D6 antibody (SEQ ID NO:7) and humanized versions of the 3D6 antibody (hu3D6VHvb1, hu3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6VHvb5, hu3D6VHvb6, and hu3D6VHvb7) with human germline heavy chain variable region sequence IGHV1-69-2*01 (SEQ ID NO:25) and with human acceptor heavy chain variable region sequence 2RCS VH hFrwk (SEQ ID NO:75). hu3D6VHvb1 is SEQ ID NO:76, hu3D6VHvb2 is SEQ ID NO:77, hu3D6VHvb3 is SEQ ID NO:78, hu3D6VHvb4 is SEQ ID NO:79, hu3D6VHvb5 is SEQ ID NO:80, hu3D6VHvb6 is SEQ ID NO:90, and hu3D6VHvb7 is SEQ ID NO:91. The CDRs as defined by Kabat/Chothia Composite are in boldface.

[0057] Figure 2 depicts an alignment of light chain variable regions of the mouse 3D6 antibody (SEQ ID NO:11) and humanized versions of the 3D6 antibody (hu3D6VLvb1, hu3D6VLvb2, and hu3D6VLvb3) with human germline light chain variable region sequence IGKV2-30*02 (SEQ ID NO:27) and with human acceptor ARX71335_VL_hFrwk (SEQ ID NO:82). hu3D6VLvb1 is SEQ ID NO:83, hu3D6VLvb2 is SEQ ID NO:84, and hu3D6VLvb3 is SEQ ID NO:85. The CDRs as defined by Kabat are in boldface.

[0058] Figures 3A, 3B, and 3C depict results of ELISA screening assays for selected mouse monoclonal anti-tau antibodies.

[0059] Figure 4 depicts binding kinetics for selected mouse monoclonal anti-tau antibodies to recombinant human tau.

[0060] Figure 5 depicts results of functional blocking assays for selected mouse monoclonal anti-tau antibodies.

[0061] Figure 6 depicts results of disaggregation assays for selected mouse monoclonal anti-tau antibodies.

[0062] Figure 7 depicts results of experiments showing that 3D6 and 5G8 immunocapture tau from human Alzheimer's disease tissue.

BRIEF DESCRIPTION OF THE SEQUENCES

[0063] SEQ ID NO:1 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-8).

[0064] SEQ ID NO:2 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-7).

[0065] SEQ ID NO:3 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-6), (4R0N human tau).

[0066] SEQ ID NO:4 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-5)

[0067] SEQ ID NO:5 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-4).

[0068] SEQ ID NO:6 sets forth the amino acid sequence of an isoform of human tau (Swiss-Prot P10636-2).

[0069] SEQ ID NO:7 sets forth the amino acid sequence of the heavy chain variable region of the mouse 3D6 antibody.

[0070] SEQ ID NO:8 sets forth the amino acid sequence of Kabat/Chothia composite CDR-H1 of the mouse 3D6 antibody.

[0071] SEQ ID NO:9 sets forth the amino acid sequence of Kabat CDR-H2 of the mouse 3D6 antibody.

[0072] SEQ ID NO:10 sets forth the amino acid sequence of Kabat CDR-H3 of the mouse 3D6 antibody.

[0073] SEQ ID NO:11 sets forth the amino acid sequence of the light chain variable region of the mouse 3D6 antibody and of the mouse 6A10 antibody.

[0074] SEQ ID NO:12 sets forth the amino acid sequence of Kabat CDR-L1 of the mouse 3D6 antibody and of the mouse 6A10 antibody.

[0075] SEQ ID NO:13 sets forth the amino acid sequence of Kabat CDR-L2 of the mouse 3D6 antibody and of the mouse 6A10 antibody.

[0076] SEQ ID NO:14 sets forth the amino acid sequence of Kabat CDR-L3 of the mouse 3D6 antibody and of the mouse 6A10 antibody.

[0077] SEQ ID NO:15 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1.

[0078] SEQ ID NO:16 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv2.

[0079] SEQ ID NO:17 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1b.

[0080] SEQ ID NO:18 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1bA11.

[0081] SEQ ID NO:19 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv5:

[0082] SEQ ID NO:20 sets forth the amino acid sequence of the light chain variable region of the humanized 3D6 antibody hu3D6VLv1.

[0083] SEQ ID NO:21 sets forth the amino acid sequence of the light chain variable region of the humanized 3D6 antibody hu3D6VLv2.

[0084] SEQ ID NO:22 sets forth the amino acid sequence of the light chain variable region of the humanized 3D6 antibody hu3D6VLv3.

[0085] SEQ ID NO:23 sets forth the amino acid sequence of the light chain variable region of the humanized 3D6 antibody hu3D6VLv4.

[0086] SEQ ID NO:24 sets forth the amino acid sequence of the heavy chain variable acceptor Acc.# BAC01986.1.

[0087] SEQ ID NO:25 sets forth the amino acid sequence of the heavy chain variable acceptor Acc.# IMGT# IGHV1-69-2*01.

[0088] SEQ ID NO:26 sets forth the amino acid sequence of the heavy chain variable acceptor Acc.# IMGT#IGKJ1*01.

[0089] SEQ ID NO:27 sets forth the amino acid sequence of the light chain variable acceptor Acc. # IMGT#IGKV2-30*02

[0090] SEQ ID NO:28 sets forth the amino acid sequence of the light chain variable acceptor Acc. # IMGT#IGKJ2*01.

[0091] SEQ ID NO:29 sets forth the amino acid sequence of the light chain variable acceptor Acc. # AAZ09048.1.

[0092] SEQ ID NO:30 sets forth a nucleic acid sequence encoding the heavy chain variable region of the mouse 3D6 antibody.

[0093] SEQ ID NO:31 sets forth a nucleic acid sequence encoding the light chain variable region of the mouse 3D6 antibody.

[0094] SEQ ID NO:32 sets forth the amino acid sequence of Kabat CDR-H1 of the mouse 3D6 antibody.

[0095] SEQ ID NO:33 sets forth the amino acid sequence of Chothia CDR-H1 of the mouse 3D6 antibody.

[0096] SEQ ID NO:34 sets forth the amino acid sequence of Chothia CDR-H2 of the mouse 3D6 antibody.

[0097] SEQ ID NO:35 sets forth the amino acid sequence of AbM CDR-H2 of the mouse 3D6 antibody.

[0098] SEQ ID NO:36 sets forth the amino acid sequence of Contact CDR-L1 of the mouse 3D6 antibody.

[0099] SEQ ID NO:37 sets forth the amino acid sequence of Contact CDR-L2 of the mouse 3D6 antibody.

[0100] SEQ ID NO:38 sets forth the amino acid sequence of Contact CDR-L3 of the mouse 3D6 antibody.

[0101] SEQ ID NO:39 sets forth the amino acid sequence of Contact CDR-H1 of the mouse 3D6 antibody.

[0102] SEQ ID NO:40 sets forth the amino acid sequence of Contact CDR-H2 of the mouse 3D6 antibody.

[0103] SEQ ID NO:41 sets forth the amino acid sequence of Contact CDR-H3 of the mouse 3D6 antibody.

[0104] SEQ ID NO:42 sets forth the amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VHv5, hu3D6VHv1bA11B6G2, hu3D6VHv1bA11B6H3, hu3D6VHv1e, and hu3D6VHv1f).

[0105] SEQ ID NO:43 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHv5 and hu3D6VHv1bA11B6H3).

[0106] SEQ ID NO:44 sets forth the consensus amino acid sequence among the heavy chain variable regions of the mouse 3D6 and selected humanized 3D6 antibodies (VHv1, VHv2, VHv1b, VHv1bA11, and VHv5) (labeled "Majority' in Figure 2 of PCT/IB2017/052544.

[0107] SEQ ID NO:45 sets forth the consensus amino acid sequence between the light chain variable regions of the mouse 3D6 and selected humanized 3D6 antibodies (labeled "Majority' in Figure 3 of PCT/IB2017/052544).

[0108] SEQ ID NO:46 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1bA11B6G2.

[0109] SEQ ID NO:47 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1bA11B6H3.

[0110] SEQ ID NO:48 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1c.

[0111] SEQ ID NO:49 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1d.

[0112] SEQ ID NO:50 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1e.

[0113] SEQ ID NO:51 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv1f.

[0114] SEQ ID NO:52 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv3.

[0115] SEQ ID NO:53 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv3b.

[0116] SEQ ID NO:54 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv3c.

[0117] SEQ ID NO:55 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv4.

[0118] SEQ ID NO:56 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv4b.

[0119] SEQ ID NO:57 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHv4c.

[0120] SEQ ID NO:58 sets forth the amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VH1c).

[0121] SEQ ID NO:59 sets forth the amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VHv1d, hu3D6VHv3c, and hu3D6VHv4c).

[0122] SEQ ID NO:60 sets forth the amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VHv3b and hu3D6VHv4b).

[0123] SEQ ID NO:61 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHv1bA11B6G2).

[0124] SEQ ID NO:62 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHv1c, hu3D6VHv3b, AND hu3D6VHv4b.

[0125] SEQ ID NO:63 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHv1d, hu3D6VHv1f, hu3D6VHv3c, and hu3D6VHv4c).

[0126] SEQ ID NO:64 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHv1e).

[0127] SEQ ID NO:65 sets forth the amino acid sequence of an alternate Kabat CDR-H3 of a humanized 3D6 antibody (as in hu3D6VHv1f).

[0128] SEQ ID NO:66 sets forth the amino acid sequence of the heavy chain variable region of the mouse 6A10 antibody.

[0129] SEQ ID NO:67 sets forth the amino acid sequence of Kabat/Chothia composite CDR-H1 of the mouse 6A10 antibody.

[0130] SEQ ID NO:68 sets forth the amino acid sequence of Kabat CDR-H2 of the mouse 6A10 antibody.

[0131] SEQ ID NO:69 sets forth the amino acid sequence of Kabat CDR-H3 of the mouse 6A10 antibody.

[0132] SEQ ID NO:70 sets for the amino acid sequence of the VH region of mouse antibody (pdb code 1CR9) used as a structure template for heavy chain humanization.

[0133] SEQ ID NO:71 sets forth the consensus amino acid sequence among the heavy chain variable regions of the selected humanized 3D6 antibodies (VHv1, VHv1b, VHv1bA11, VHv1bA11B6G2, VHv1bA11B6H3, VHv1c, VHv1d, VHv1e, VHv1f, VHv2, VHv3, VHv3b, VHv3c, VHv4, VHv4b, VHv4c, and VHv5) (labeled “Majority’ in Figures 4A and 4B of PCT/IB2017/052544).

[0134] SEQ ID NO:72 sets forth the amino acid sequence of the heavy chain of a chimeric 3D6 antibody.

[0135] SEQ ID NO:73 sets forth the amino acid sequence of the light chain of a chimeric 3D6 antibody.

[0136] SEQ ID NO:74 sets forth the amino acid sequence of heavy chain variable structural model Acc.# 5MYX-VH_mSt.

[0137] SEQ ID NO:75 sets forth the amino acid sequence of heavy chain variable acceptor Acc.# 2RCS-VH_huFrwk.

[0138] SEQ ID NO:76 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb1.

[0139] SEQ ID NO:77 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb2.

[0140] SEQ ID NO:78 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb3.

[0141] SEQ ID NO:79 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb4.

[0142] SEQ ID NO:80 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb5.

[0143] SEQ ID NO:81 sets forth the amino acid sequence of light chain variable structural model Acc.# 5MYX-VL_mSt.

[0144] SEQ ID NO:82 sets forth the amino acid sequence of light chain variable acceptor Acc.# ARX71335-VL_huFrwk.

[0145] SEQ ID NO:83 sets forth the amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb1.

[0146] SEQ ID NO:84 sets forth the amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb2.

[0147] SEQ ID NO:85 sets forth the amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb3.

[0148] SEQ ID NO:86 sets forth the amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VHvb4 and hu3D6VHvb5).

[0149] SEQ ID NO:87 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb3 and hu3D6VHvb4).

[0150] SEQ ID NO:88 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb5).

[0151] SEQ ID NO:89 sets forth the amino acid sequence of an alternate Kabat CDR-L1 of a humanized 3D6 antibody (as in hu3D6VLvb3).

[0152] SEQ ID NO:90 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb6.

[0153] SEQ ID NO:91 sets forth the amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb7.

[0154] SEQ ID NO:92 sets forth the amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb6 and hu3D6VHvb7).

[0155] SEQ ID NO:93 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb1.

[0156] SEQ ID NO:94 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb2.

[0157] SEQ ID NO:95 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb3.

[0158] SEQ ID NO:96 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb4.

[0159] SEQ ID NO:97 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb5.

[0160] SEQ ID NO:98 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb6.

[0161] SEQ ID NO:99 sets forth a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb7.

[0162] SEQ ID NO:100 sets forth a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb1.

[0163] SEQ ID NO:101 sets forth a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb2.

[0164] SEQ ID NO:102 sets forth a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb3.

[0165] SEQ ID NO:103 sets forth the amino acid sequence of an exemplary IgG1 heavy chain constant region.

[0166] SEQ ID NO:104 sets forth the amino acid sequence of an exemplary kappa light chain constant region.

[0167] SEQ ID NO:105 sets forth a nucleic acid sequence encoding an exemplary IgG1 heavy chain constant region.

[0168] SEQ ID NO:106 sets forth a nucleic acid sequence encoding an exemplary kappa light chain constant region.

DEFINITIONS

[0169] Monoclonal antibodies or other biological entities are typically provided in isolated form. This means that an antibody or other biologically entity 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 monoclonal antibody is combined with an excess of pharmaceutically acceptable carrier(s) or other vehicle intended to facilitate its use. Sometimes monoclonal antibodies are at least 60%, 70%, 80%, 90%, 95% or 99% w/w pure of interfering proteins and contaminants from production or purification. Often an isolated monoclonal antibody or other biological entity is the predominant macromolecular species remaining after its purification.

[0170] Specific binding of an antibody to its target antigen means an affinity and/or avidity of at least 10^6, 10^7, 10^8, 10^9, 10^{10}, 10^{11}, or 10^{12} M^{-1}. Specific binding is detectably higher in magnitude and distinguishable from non-specific binding occurring to at least one unrelated target. Specific binding can be the result of formation of bonds between particular functional groups or particular spatial fit (*e.g.*, lock and key type) whereas nonspecific binding is usually the result of van der Waals forces. Specific binding does not however necessarily imply that an antibody binds one and only one target.

[0171] The basic antibody structural unit is a tetramer of subunits. Each tetramer includes two identical pairs of polypeptide chains, each pair having one "light" (about 25 kDa) and one "heavy" chain (about 50-70 kDa). The amino-terminal portion of each chain includes a variable region of about 100 to 110 or more amino acids primarily responsible for antigen recognition. This variable region is initially expressed linked to a cleavable signal peptide. The variable region without the signal peptide is sometimes referred to as a mature variable region. Thus, for example, a light chain mature variable region means a light chain variable region without the light chain signal peptide. The carboxy-terminal portion of each chain defines a constant region primarily responsible for effector function.

[0172] Light chains are classified as either kappa or lambda. Heavy chains are classified as gamma, mu, alpha, delta, or epsilon, and define the antibody's isotype as IgG, IgM, IgA, IgD and IgE, respectively. Within light and heavy chains, the variable and constant regions are joined by a "J" region of about 12 or more amino acids, with the heavy chain also including a "D" region of about 10 or more amino acids. *See generally*, *Fundamental Immunology*, Paul, W., ed., 2nd ed. Raven Press, N.Y., 1989, Ch. 7 (incorporated by reference in its entirety for all purposes).

[0173] An immunoglobulin light or heavy chain variable region (also 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 referred to herein, respectively, as CDR-L1, CDR-L2, and CDR-L3; CDRs 1, 2, and 3 of a VH domain are also 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.

[0174] 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 1). 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 1

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.

[0175] 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 including separate heavy chains, light chains Fab, Fab', $F(ab')_2$, F(ab)c, Dabs, nanobodies, and Fv. 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 and/or a humanized 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)). In some bispecific antibodies, the two different heavy/light chain pairs include a humanized 3D6 heavy chain/light chain pair and a heavy chain/light chain pair specific for a different epitope on tau than that bound by 3D6.

[0176] In some bispecific antibodies, one heavy chain/light chain pair is a humanized 3D6 antibody as further disclosed below and the other heavy chain/light chain pair is from an antibody that binds to a receptor expressed on the blood brain barrier, such as an insulin receptor, an insulin-like growth factor (IGF) receptor, a leptin receptor, or a lipoprotein receptor, or a transferrin receptor (Friden *et al.*, *Proc. Natl. Acad. Sci. USA* 88:4771-4775, 1991; Friden *et al.*, *Science* 259:373-377, 1993). Such a bispecific antibody can be transferred cross the blood brain barrier by receptor-mediated transcytosis. Brain uptake of the bispecific antibody can be further enhanced by engineering the bi-specific antibody to reduce its affinity to the blood brain barrier receptor. Reduced affinity for the receptor resulted in a broader distribution in the brain (*see, e.g.*, Atwal *et al.*, *Sci. Trans. Med.* 3, 84ra43, 2011; Yu *et al.*, *Sci. Trans. Med.* 3, 84ra44, 2011).

[0177] Exemplary bispecific antibodies can also be: (1) a dual-variable-domain antibody (DVD-Ig), where each light chain and heavy chain contains two variable domains in tandem through a short peptide linkage (Wu *et al.*, Generation and Characterization of a Dual Variable Domain Immunoglobulin (DVD-Ig™) Molecule, In: Antibody Engineering, Springer Berlin Heidelberg (2010)); (2) a Tandab, which is a fusion of two single chain diabodies resulting in a tetravalent bispecific antibody that has two binding sites for each of the target antigens; (3) a flexibody, which is a combination of scFvs with a diabody resulting in a multivalent molecule; (4) a so-called "dock and lock" molecule, based on the "dimerization and docking domain" in Protein Kinase A, which, when applied to Fabs, can yield a trivalent bispecific binding protein consisting of two identical Fab fragments linked to a different Fab fragment; or (5) a so-called Scorpion molecule, comprising, *e.g.*, two scFvs fused to both termini of a human Fc-region.

Examples of platforms useful for preparing bispecific antibodies include BiTE (Micromet), DART (MacroGenics), Fcab and Mab2 (F-star), Fc-engineered IgGl (Xencor) or DuoBody (based on Fab arm exchange, Genmab).

[0178] The term "epitope" 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 (also known as linear epitopes) are typically retained on exposure to denaturing solvents whereas epitopes formed by tertiary folding (also known as conformational epitopes) 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. 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).

[0179] Antibodies that recognize the same or overlapping epitopes can be identified in a simple immunoassay showing the ability of one antibody to compete with the binding of another antibody to a target antigen. The epitope of an antibody can also be defined 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.

[0180] Competition between antibodies is determined by an assay in which an antibody under test inhibits specific binding of a reference antibody 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 2x, 5x, 10x, 20x or 100x) inhibits binding of the reference antibody by at least 50% as measured in a competitive binding assay. Some test antibodies inhibit binding of the reference antibody by at least 75%, 90% or 99%. 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.

[0181] The term "pharmaceutically acceptable" means that the carrier, diluent, excipient, or auxiliary is compatible with the other ingredients of the formulation and not substantially deleterious to the recipient thereof.

[0182] The term "patient" includes human and other mammalian subjects that receive either prophylactic or therapeutic treatment.

[0183] 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, and situational exposure) placing individuals with that risk factor at a statistically significant greater risk of developing the disease than individuals without the risk factor.

[0184] The term "biological sample" refers to a sample of biological material within or obtainable from a biological source, for example a human or mammalian subject. Such samples can be organs, organelles, tissues, sections of tissues, bodily fluids, peripheral blood, blood plasma, blood serum, cells, molecules such as proteins and peptides, and any parts or combinations derived therefrom. The term biological sample can also encompass any material derived by processing the sample. Derived material can include cells or their progeny. Processing of the biological sample may involve one or more of filtration, distillation, extraction, concentration, fixation, inactivation of interfering components, and the like.

[0185] The term "control sample" refers to a biological sample not known or suspected to include tau-related disease-affected regions, or at least not known or suspect to include diseased regions of a given type. Control samples can be obtained from individuals not afflicted with the tau-related disease. Alternatively, control samples can be obtained from patients afflicted with the tau-related disease. Such samples can be obtained at the same time as a biological sample thought to comprise the tau-related disease or on a different occasion. A biological sample and a control sample can both be obtained from the same tissue. Preferably, control samples consist essentially or entirely of normal, healthy regions and can be used in comparison to a biological sample thought to comprise tau-related disease-affected regions. Preferably, the tissue in the control sample is the same type as the tissue in the biological sample. Preferably, the tau-related

disease-affected cells thought to be in the biological sample arise from the same cell type (*e.g.*, neurons or glia) as the type of cells in the control sample.

[0186] The term “disease” refers to any abnormal condition that impairs physiological function. The term is used broadly to encompass any disorder, illness, abnormality, pathology, sickness, condition, or syndrome in which physiological function is impaired, irrespective of the nature of the etiology.

[0187] The term “symptom” refers to a subjective evidence of a disease, such as altered gait, as perceived by the subject. A "sign" refers to objective evidence of a disease as observed by a physician.

[0188] The term “positive response to treatment” refers to a more favorable response in an individual patient or average response in a population of patients relative to an average response in a control population not receiving treatment.

[0189] For purposes of classifying amino acids substitutions as conservative or nonconservative, amino acids are grouped as follows: Group I (hydrophobic side chains): met, ala, val, leu, ile; Group II (neutral hydrophilic side chains): cys, ser, thr; Group III (acidic side chains): asp, glu; Group IV (basic side chains): asn, gln, his, lys, arg; Group V (residues influencing chain orientation): gly, pro; and Group VI (aromatic side chains): trp, tyr, phe. Conservative substitutions involve substitutions between amino acids in the same class. Non-conservative substitutions constitute exchanging a member of one of these classes for a member of another.

[0190] Percentage sequence identities are determined with antibody sequences maximally aligned by the Kabat numbering convention. After alignment, if a subject antibody region (*e.g.*, the entire mature variable region of a heavy or light chain) is being compared with the same region of a reference antibody, the percentage sequence identity between the subject and reference antibody regions is the number of positions occupied by the same amino acid in both the subject and reference antibody region divided by the total number of aligned positions of the two regions, with gaps not counted, multiplied by 100 to convert to percentage.

[0191] Compositions or methods “comprising” or “including” one or more recited elements may include other elements not specifically recited. For example, a composition that

"comprises" or "includes" an antibody may contain the antibody alone or in combination with other ingredients.

[0192] Designation of a range of values includes all integers within or defining the range, and all subranges defined by integers within the range.

[0193] Unless otherwise apparent from the context, the term "about" encompasses insubstantial variations, such as values within a standard margin of error of measurement (*e.g.*, SEM) of a stated value.

[0194] Statistical significance means $p \leq 0.05$.

[0195] The singular forms of the articles "a," "an," and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" can include a plurality of compounds, including mixtures thereof.

DETAILED DESCRIPTION

I. General

[0196] The invention provides antibodies that bind to tau. Some antibodies specifically bind to epitopes within the microtubule binding region (MTBR) region of human tau. Some antibodies bind to tau irrespective of phosphorylation state. Some antibodies of the invention serve to inhibit or delay tau-associated pathologies and associated symptomatic deterioration. Although an understanding of mechanism is not required for practice of the invention, a reduction in toxicity may occur as a result of the antibody inducing phagocytosis of tau, inhibiting tau from inter or intramolecular aggregation, or from binding to other molecules, by stabilizing a non-toxic conformation, by inhibiting intercellular or intracellular transmission of pathogenic tau forms, by blockade of tau phosphorylation, by preventing binding of tau to cells, or by inducing proteolytic cleavage of tau, among other mechanisms. The antibodies of the invention or agents that induce such antibodies can be used in methods of treating or effecting prophylaxis of Alzheimer's and other diseases associated with tau.

II. Target Molecules

[0197] Unless otherwise apparent from the context, reference to tau means a natural human form of tau including all isoforms irrespective of whether posttranslational modification (*e.g.*, phosphorylation, glycation, or acetylation) is present. There are six major isoforms (splice variants) of tau occurring in the human brain. The longest of these variants has 441 amino acids, of which the initial met residue is cleaved. Residues are numbered according to the 441 isoform. Thus, for example, reference to a phosphorylation at position 404 means position 404 of the 441 isoform, or corresponding position of any other isoform when maximally aligned with the 441 isoform. The amino acid sequences of the isoforms and Swiss-Prot numbers are indicated below.

P10636-8 (SEQ ID NO:1)

```
          10         20         30         40         50         60
MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKESPLQT PTEDGSEEPG
          70         80         90        100        110        120
SETSDAKSTP TAEDVTAPLV DEGAPGKQAA AQPHTEIPEG TTAEEAGIGD TPSLEDEAAG
         130        140        150        160        170        180
HVTQARMVSK SKDGTGSDDK KAKGADGKTK IATPRGAAPP GQKGQANATR IPAKTPPAPK
         190        200        210        220        230        240
TPPSSGEPPK SGDRSGYSSP GSPGTPGSRS RTPSLPTPPT REPKKVAVVR TPPKSPSSAK
         250        260        270        280        290        300
SRLQTAPVPM PDLKNVKSKI GSTENLKHQP GGGKVQIINK KLDLSNVQSK CGSKDNIKHV
         310        320        330        340        350        360
PGGGSVQIVY KPVDLSKVTS KCGSLGNIHH KPGGGQVEVK SEKLDFKDRV QSKIGSLDNI
         370        380        390        400        410        420
THVPGGGNKK IETHKLTFRE NAKAKTDHGA EIVYKSPVVS GDTSPRHLSN VSSTGSIDMV
         430        440
DSPQLATLAD EVSASLAKQG L
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P10636-7 (SEQ ID NO:2)

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          10         20         30         40         50         60
MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKESPLQT PTEDGSEEPG
          70         80         90        100        110        120
SETSDAKSTP TAEAEEAGIG DTPSLEDEAA GHVTQARMVS KSKDGTGSDD KKAKGADGKT
         130        140        150        160        170        180
KIATPRGAAP PGQKGQANAT RIPAKTPPAP KTPPSSGEPP KSGDRSGYSS PGSPGTPGSR
         190        200        210        220        230        240
SRTPSLPTPP TREPKKVAVV RTPPKSPSSA KSRLQTAPVP MPDLKNVKSK IGSTENLKHQ
         250        260        270        280        290        300
PGGGKVQIIN KKLDLSNVQS KCGSKDNIKH VPGGGSVQIV YKPVDLSKVT SKCGSLGNIH
         310        320        330        340        350        360
HKPGGGQVEV KSEKLDFKDR VQSKIGSLDN ITHVPGGGNK KIETHKLTFR ENAKAKTDHG
         370        380        390        400        410
AEIVYKSPVV SGDTSPRHLS NVSSTGSIDM VDSPQLATLA DEVSASLAKQ GL
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P10636-6 (4R0N human tau) (SEQ ID NO:3)

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          10         20         30         40         50         60
MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKAEEAGI GDTPSLEDEA
          70         80         90        100        110        120
AGHVTQARMV SKSKDGTGSD DKKAKGADGK TKIATPRGAA PPGQKGQANA TRIPAKTPPA
         130        140        150        160        170        180
PKTPPSSGEP PKSGDRSGYS SPGSPGTPGS RSRTPSLPTP PTREPKKVAV VRTPPKSPSS
         190        200        210        220        230        240
AKSRLQTAPV PMPDLKNVKS KIGSTENLKH QPGGGKVQII NKKLDLSNVQ SKCGSKDNIK
         250        260        270        280        290        300
HVPGGGSVQI VYKPVDLSKV TSKCGSLGNI HHKPGGGQVE VKSEKLDFKD RVQSKIGSLD
         310        320        330        340        350        360
NITHVPGGGN KKIETHKLTF RENAKAKTDH GAEIVYKSPV VSGDTSPRHL SNVSSTGSID
         370        380
MVDSPQLATL ADEVSASLAK QGL
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P10636-5 (SEQ ID NO:4)

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          10         20         30         40         50         60
MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKESPLQT PTEDGSEEPG
          70         80         90        100        110        120
SETSDAKSTP TAEDVTAPLV DEGAPGKQAA AQPHTEIPEG TTAEEAGIGD TPSLEDEAAG
         130        140        150        160        170        180
HVTQARMVSK SKDGTGSDDK KAKGADGKTK IATPRGAAPP GQKGQANATR IPAKTPPAPK
         190        200        210        220        230        240
TPPSSGEPPK SGDRSGYSSP GSPGTPGSRS RTPSLPTPPT REPKKVAVVR TPPKSPSSAK
         250        260        270        280        290        300
SRLQTAPVPM PDLKNVKSKI GSTENLKHQP GGGKVQIVYK PVDLSKVTSK CGSLGNIHHK
         310        320        330        340        350        360
PGGGQVEVKS EKLDFKDRVQ SKIGSLDNIT HVPGGGNKKI ETHKLTFREN AKAKTDHGAE
         370        380        390        400        410
IVYKSPVVSG DTSPRHLSNV SSTGSIDMVD SPQLATLADE VSASLAKQGL
```

P10636-4 (SEQ ID NO:5)

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          10         20         30         40         50         60
MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKESPLQT PTEDGSEEPG
          70         80         90        100        110        120
SETSDAKSTP TAEAEEAGIG DTPSLEDEAA GHVTQARMVS KSKDGTGSDD KKAKGADGKT
         130        140        150        160        170        180
KIATPRGAAP PGQKGQANAT RIPAKTPPAP KTPPSSGEPP KSGDRSGYSS PGSPGTPGSR
         190        200        210        220        230        240
SRTPSLPTPP TREPKKVAVV RTPPKSPSSA KSRLQTAPVP MPDLKNVKSK IGSTENLKHQ
         250        260        270        280        290        300
PGGGKVQIVY KPVDLSKVTS KCGSLGNIHH KPGGGQVEVK SEKLDFKDRV QSKIGSLDNI
         310        320        330        340        350        360
THVPGGGNKK IETHKLTFRE NAKAKTDHGA EIVYKSPVVS GDTSPRHLSN VSSTGSIDMV
         370        380
DSPQLATLAD EVSASLAKQG L
```

P10636-2 (SEQ ID NO:6)

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10         20         30         40         50         60
```

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MAEPRQEFEV MEDHAGTYGL GDRKDQGGYT MHQDQEGDTD AGLKAEEAGI GDTPSLEDEA

        70          80          90         100         110         120
AGHVTQARMV SKSKDGTGSD DKKAKGADGK TKIATPRGAA PPGQKGQANA TRIPAKTPPA

       130         140         150         160         170         180
PKTPPSSGEP PKSGDRSGYS SPGSPGTPGS RSRTPSLPTP PTREPKKVAV VRTPPKSPSS

       190         200         210         220         230         240
AKSRLQTAPV PMPDLKNVKS KIGSTENLKH QPGGGKVQIV YKPVDLSKVT SKCGSLGNIH

       250         260         270         280         290         300
HKPGGGQVEV KSEKLDFKDR VQSKIGSLDN ITHVPGGGNK KIETHKLTFR ENAKAKTDHG

       310         320         330         340         350
AEIVYKSPVV SGDTSPRHLS NVSSTGSIDM VDSPQLATLA DEVSASLAKQ GL
```

[0198] Reference to tau includes known natural variations about 30 of which are listed in the Swiss-Prot database and permutations thereof, as well as mutations associated with tau pathologies, such as dementia, Pick's disease, supranuclear palsy, etc. (see, *e.g.*, Swiss-Prot database and Poorkaj, et al. Ann Neurol. 43:815-825 (1998)). Some examples of tau mutations numbered by the 441 isoform are a lysine to threonine mutation at amino acid residue 257 (K257T), an isoleucine to valine mutation at amino acid position 260 (I260V); a glycine to valine mutation at amino acid position 272 (G272V); an asparagine to lysine mutation at amino acid position 279 (N279K); an asparagine to histidine mutation at amino acid position 296 (N296H); a proline to serine mutation at amino acid position 301 (P301S); a proline to leucine mutation at amino acid 301 (P301L); a glycine to valine mutation at amino acid position 303 (G303V); a serine to asparagine mutation at position 305 (S305N); a glycine to serine mutation at amino acid position 335 (G335S); a valine to methionine mutation at position 337 (V337M); a glutamic acid to valine mutation at position 342 (E342V); a lysine to isoleucine mutation at amino acid position 369 (K3691); a glycine to arginine mutation at amino acid position 389 (G389R); and an arginine to tryptophan mutation at amino acid position 406 (R406W).

[0199] Tau can be phosphorylated at one or more amino acid residues including tyrosine at amino acid positions 18, 29, 97, 310, and 394 serine at amino acid positions 184, 185, 198, 199, 202, 208, 214, 235, 237, 238, 262, 293, 324, 356, 396, 400, 404, 409, 412, 413, and 422; and threonine at amino acids positions 175, 181, 205, 212, 217, 231, and 403.

Unless otherwise apparent from context, reference to tau, or their fragments includes the natural human amino acid sequences including isoforms, mutants, and allelic variants thereof.

III. Antibodies

A. Binding Specificity and Functional Properties

[0200] The invention provides antibodies that bind to tau. Some antibodies specifically bind to epitopes within the microtubule binding region (MTBR) region of human tau. Some antibodies bind to tau irrespective of phosphorylation state. Some antibodies bind to an epitope not including a residue subject to phosphorylation. These antibodies can be obtained by immunizing with a tau polypeptide purified from a natural source or recombinantly expressed. Antibodies can be screened for binding tau in unphosphorylated form as well as a form in which one or more residues susceptible to phosphorylation are phosphorylated. Such antibodies preferably bind with indistinguishable affinities or at least within a factor of 1.5, 2 or 3-fold to phosphorylated tau compared to non-phosphorylated tau (*i.e.*, are "pan-specific"). 3D6 is an example of a pan-specific monoclonal antibody. The invention also provides antibodies binding to the same epitope as any of the foregoing antibodies, such as, for example, the epitope of 3D6. Also included are antibodies competing for binding to tau with any of the foregoing antibodies, such as, for example, competing with 3D6.

[0201] Unless otherwise apparent from context, reference to 3D6 should be understood as referring to any of the mouse, chimeric, veneered, and humanized forms of this antibody. The antibody has been deposited as [DEPOSIT NUMBER]. This antibody specifically binds within the MTBR region of SEQ ID NO:1). This antibody is further characterized by its ability to bind both phosphorylated and unphosphorylated tau, both non-pathological and pathological forms and conformations of tau, and misfolded/aggregated forms of tau. An antibody designated 6A10 is another such exemplary mouse antibody. Unless otherwise apparent from context, reference to 6A10 should be understood as referring to any of the mouse, chimeric, veneered, and humanized forms of this antibody. Kabat/Chothia Composite CDRs of the heavy chain of 6A10 are designated SEQ ID NOs:67, 68, and 69, respectively, and Kabat CDRs of the light chain of 6A10 are designated SEQ ID NOs:12, 13, and 14, respectively. Mouse 6A10 shares 82.1% of

VH sequence identity and 100% VL sequence identity with the VH chain and VL chain, respectively, of mouse 3D6.

[0202] Some antibodies of the invention bind to the same or overlapping epitope as an antibody designated 3D6. The sequences of the heavy and light chain mature variable regions of this antibody are designated SEQ ID NOs:7 and 11, respectively.

[0203] Kabat/Chothia Composite CDRs of the heavy chain of 3D6 are designated SEQ ID NOs:8, 9, and 10, respectively, and Kabat CDRs of the light chain of 3D6 are designated SEQ ID NOs:12, 13, and 14, respectively.

[0204] Table 2 indicates the 3D6 CDRs as defined by Kabat, Chothia, Composite of Chothia and Kabat (also referred to herein as "Kabat/Chothia Composite"), AbM, and Contact.

Table 2: 3D6 CDRs as defined by Kabat, Chothia, Composite of Chothia and Kabat, AbM, and Contact

Loop	Kabat	Chothia	Composite of Chothia & Kabat	AbM	Contact
L1	L24--L34 SEQ ID NO:12	L24--L34 SEQ ID NO:12	L24--L34 SEQ ID NO:12	L24--L34 SEQ ID NO:12	L30--L36 SEQ ID NO:36
L2	L50--L56 SEQ ID NO:13	L50--L56 SEQ ID NO:13	L50--L56 SEQ ID NO:13	L50--L56 SEQ ID NO:13	L46--L55 SEQ ID NO:37
L3	L89--L97 SEQ ID NO:14	L89--L97 SEQ ID NO:14	L89--L97 SEQ ID NO:14	L89--L97 SEQ ID NO:14	L89--L96 SEQ ID NO:38
H1	H31--H35B SEQ ID NO:32	H26--H32 SEQ ID NO:33	H26--H35B SEQ ID NO:8	H26--H35B SEQ ID NO:8	H30--H35B SEQ ID NO:39
H2	H50--H65 SEQ ID NO:9	H52--H56 SEQ ID NO:34	H50--H65 SEQ ID NO:9	H50--H58 SEQ ID NO:35	H47--H58 SEQ ID NO:40
H3	H95--H102 SEQ ID NO:10	H95--H102 SEQ ID NO:10	H95--H102 SEQ ID NO:10	H95--H102 SEQ ID NO:10	H93--H101 SEQ ID NO:41

[0205] Other antibodies can be obtained by mutagenesis of cDNA encoding the heavy and light chains of an exemplary antibody, such as 3D6. Monoclonal antibodies that are at least 70%, 80%, 90%, 95%, 96%, 97%, 98%, or 99% identical to 3D6 or any other exemplified antibody or antibody chain in amino acid sequence of the mature heavy and/or light chain variable regions and maintain its functional properties, and/or which differ from the respective antibody by a small number of functionally inconsequential amino acid substitutions (*e.g.*,

conservative substitutions), deletions, or insertions are also included in the invention. Monoclonal antibodies having at least one or all six CDR(s) as defined by any conventional definition, but preferably Kabat, that are 90%, 95%, 99% or 100% identical to corresponding CDRs of 3D6 are also included.

[0206] The invention also provides antibodies having some or all (*e.g.*, 3, 4, 5, and 6) CDRs entirely or substantially from 3D6. Such antibodies can include a heavy chain variable region that has at least two, and usually all three, CDRs entirely or substantially from the heavy chain variable region of 3D6 and/or a light chain variable region having at least two, and usually all three, CDRs entirely or substantially from the light chain variable region of3D6. The antibodies can include both heavy and light chains. A CDR is substantially from a corresponding 3D6 CDR when it contains no more than 4, 3, 2, or 1 substitutions, insertions, or deletions, except that CDR-H2 (when defined by Kabat) can have no more than 6, 5, 4, 3, 2, or 1 substitutions, insertions, or deletions. Such antibodies can have at least 70%, 80%, 90%, 95%, 96%, 97%, 98%, or 99% identity to 3D6 in the amino acid sequence of the mature heavy and/or light chain variable regions and maintain their functional properties, and/or differ from 3D6 by a small number of functionally inconsequential amino acid substitutions (*e.g.*, conservative substitutions), deletions, or insertions.

[0207] Some antibodies identified by such assays can bind to monomeric, misfolded, aggregated, phosphorylated, or unphosphorylated forms of tau or otherwise. Likewise, some antibodies are immunoreactive on non-pathological and pathological forms and conformations of tau.

B. Humanized Antibodies

[0208] A humanized antibody is a genetically engineered antibody in which CDRs from a non-human "donor" antibody are grafted into human "acceptor" antibody sequences (see, e.g., Queen, US 5,530,101 and 5,585,089; Winter, US 5,225,539; Carter, US 6,407,213; Adair, US 5,859,205; and Foote, US 6,881,557). The acceptor antibody sequences can be, for example, a mature human antibody sequence, a composite of such sequences, a consensus sequence of human antibody sequences, or a germline region sequence. Thus, a humanized antibody is an antibody having at least three, four, five or all CDRs entirely or substantially from a donor

antibody and variable region framework sequences and constant regions, if present, entirely or substantially from human antibody sequences. Similarly a humanized heavy chain has at least one, two and usually all three CDRs entirely or substantially from a donor antibody heavy chain, and a heavy chain variable region framework sequence and heavy chain constant region, if present, substantially from human heavy chain variable region framework and constant region sequences. Similarly a humanized light chain has at least one, two and usually all three CDRs entirely or substantially from a donor antibody light chain, and a light chain variable region framework sequence and light chain constant region, if present, substantially from human light chain variable region framework and constant region sequences. Other than nanobodies and dAbs, a humanized antibody comprises a humanized heavy chain and a humanized light chain. A CDR in a humanized antibody is substantially from a corresponding CDR in a non-human antibody when at least 85%, 90%, 95% or 100% of corresponding residues (as defined by any conventional definition but preferably defined by Kabat) are identical between the respective CDRs. The variable region framework sequences of an antibody chain or the constant region of an antibody chain are substantially from a human variable region framework sequence or human constant region respectively when at least 85%, 90%, 95% or 100% of corresponding residues defined by Kabat are identical. To be classified as humanized under the 2014 World Health Organization (WHO) International non-proprietary names (INN) definition of humanized antibodies, an antibody must have at least 85% identity to human germline antibody sequences (i.e., prior to somatic hypermutation). Mixed antibodies are antibodies for which one antibody chain (e.g., heavy chain) meets the threshold but the other chain (e.g., light chain) does not meet the threshold. An antibody is classified as chimeric if neither chain meets the threshold, even though the variable framework regions for both chains were substantially human with some murine backmutations. See, Jones et al. (2016) The INNs and outs of antibody nonproprietary names, mAbs 8:1, 1-9, DOI: 10.1080/19420862.2015.1114320. See also "WHO-INN: International nonproprietary names (INN) for biological and biotechnological substances (a review)" (Internet) 2014. Available from: http://www.who.int/medicines/services/inn/BioRev2014.pdf), incorporated herein by reference. For the avoidance of doubt, the term "humanized" as used herein is not intended to be limited to the 2014 WHO INN definition of humanized antibodies. Some of the humanized antibodies

provided herein have at least 85% sequence identity to human germline sequences and some of the humanized antibodies provided herein have less than 85% sequence identity to human germline sequences. Some of the heavy chains of the humanized antibodies provided herein have from about 60% to 100% sequence identity to human germ line sequences, such as, for example, in the range of about 60% to 69%, 70% to 79%, 80% to 84%, or 85% to 89%. Some heavy chains fall below the 2014 WHO INN definition and have, for example, about 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, or 82%, 83%, or 84% sequence identity to human germ line sequences, while other heavy chains meet the 2014 WHO INN definition and have about 85%, 86%, 87%, 88%, 89% or greater sequence identity to human germ line sequences. Some of the light chains of the humanized antibodies provided herein have from about 60% to 100% sequence identity to human germ line sequences, such as, for example, in the range of about 80% to 84% or 85% to 89%. Some light chains fall below the 2014 WHO INN definition and have, for example, about 81%, 82%, 83% or 84% sequence identity to human germ line sequences, while other light chains meet the 2014 WHO INN definition and have about 85%, 86%, 87%, 88%, 89% or greater sequence identity to human germ line sequences. Some humanized antibodies provided herein that are "chimeric" under the 2014 WHO INN definition have heavy chains with less than 85% identity to human germ line sequences paired with light chains having less than 85% identity to human germ line sequences. Some humanized antibodies provided herein are "mixed" under the 2014 WHO INN definition, for example, having a heavy chain with at least 85% sequence identity to human germ line sequences paired with a light chain having less than 85% sequence identity to human germ line sequences, or vice versa. Some humanized antibodies provided herein meet the 2014 WHO INN definition of "humanized" and have a heavy chain with at least 85% sequence identity to human germ line sequences paired with a light chain having at least 85% sequence identity to human germ line sequences. Additional humanized antibodies of the invention meet the 2014 WHO INN definition of "mixed."

[0209] Although humanized antibodies often incorporate all six CDRs (defined by any conventional definition but preferably as defined by Kabat) from a mouse antibody, they can also be made with less than all CDRs (*e.g.*, at least 3, 4, or 5 CDRs) from a mouse antibody (*e.g.*, Pascalis *et al.*, *J. Immunol.* 169:3076, 2002; Vajdos *et al.*, *J. of Mol. Biol.*, 320: 415-428, 2002;

Iwahashi *et al.*, *Mol. Immunol.* 36:1079-1091, 1999; Tamura *et al*, *J. Immunol.*, 164:1432-1441, 2000).

[0210] In some antibodies only part of the CDRs, namely the subset of CDR residues required for binding, termed the SDRs, are needed to retain binding in a humanized antibody. CDR residues not contacting antigen and not in the SDRs can be identified based on previous studies (for example residues H60-H65 in CDR H2 are often not required), from regions of Kabat CDRs lying outside Chothia hypervariable loops (Chothia, *J. Mol. Biol.* 196:901, 1987), by molecular modeling and/or empirically, or as described in Gonzales *et al.*, *Mol. Immunol.* 41: 863, 2004. In such humanized antibodies at positions in which one or more donor CDR residues is absent or in which an entire donor CDR is omitted, the amino acid occupying the position can be an amino acid occupying the corresponding position (by Kabat numbering) in the acceptor antibody sequence. The number of such substitutions of acceptor for donor amino acids in the CDRs to include reflects a balance of competing considerations. Such substitutions are potentially advantageous in decreasing the number of mouse amino acids in a humanized antibody and consequently decreasing potential immunogenicity and/or for meeting the WHO INN definition of "humanized". However, substitutions can also cause changes of affinity, and significant reductions in affinity are preferably avoided. Positions for substitution within CDRs and amino acids to substitute can also be selected empirically.

[0211] The human acceptor antibody sequences can optionally be selected from among the many known human antibody sequences to provide a high degree of sequence identity (*e.g.*, 65-85% identity) between a human acceptor sequence variable region frameworks and corresponding variable region frameworks of a donor antibody chain.

[0212] An example of an acceptor sequence for the heavy chain is the human mature heavy chain variable region of humanized 48G7 Fab with PDB accession code 2RCS-VH_huFrwk (SEQ ID NO:75). The variable domains of 3D6 and 48G7 Fab also share identical lengths for the CDR-H1, H2 loops. Another example of an acceptor sequence for the heavy chain is the human mature heavy chain variable region IMGT# IGHV1-69-2*01 (SEQ ID NO:25). IMGT# IGHV1-69-2*01 (SEQ ID NO:25) shares the canonical form of mouse 3D6 heavy chain CDR-H1 and H2. IMGT# IGHV1-69-2*01 (SEQ ID NO:25) belongs to human heavy chain subgroup

1. An example of an acceptor sequence for the light chain is the human mature light chain variable region with PDB accession code human antibody ARX71335 VL (SEQ ID NO:82). The variable light domain of 3D6 and ARX71335 antibody also share identical lengths for the CDR-L1, L2 and L3 loops. Another example of an acceptor sequence for the light chain is the human mature light chain variable region with IMGT#IGKV2-30*02 (SEQ ID NO:27). IMGT#IGKV2-30*02 (SEQ ID NO:27) has the same canonical classes for CDR-L1, CDR-L2 and L3 as mouse 3D6. IMGT#IGKV2-30*02 (SEQ ID NO:27) belongs to human kappa subgroup 2.

[0213] If more than one human acceptor antibody sequence is selected, a composite or hybrid of those acceptors can be used, and the amino acids used at different positions in the humanized light chain and heavy chain variable regions can be taken from any of the human acceptor antibody sequences used. For example, the human mature heavy chain variable regions of IMGT# IGHV1-69-2*01 (SEQ ID NO:25) and PDB accession code # 2RCS-VH_huFrwk (SEQ ID NO:75) were used as acceptor sequences for humanization of the 3D6 mature heavy chain variable region. An example of a positions in which these two acceptors differ is position H17 (T or S). Humanized versions of the3D6 heavy chain variable region can include either amino acid at this position. For example, the human mature light chain variable regions IMGT# IGKV2-30*02 (SEQ ID NO:27) and PDB code # ARX71335-VL_huFrwk (SEQ ID NO:82) were used as acceptor sequences for humanization of the 3D6 mature light chain variable region. An example of a position in which these two acceptors differ is position L100 (Q or A). Humanized versions of the3D6 light chain variable region can include either amino acid at this position.

[0214] Certain amino acids from the human variable region framework residues can be selected for substitution based on their possible influence on CDR conformation and/or binding to antigen. Investigation of such possible influences is by modeling, examination of the characteristics of the amino acids at particular locations, or empirical observation of the effects of substitution or mutagenesis of particular amino acids.

[0215] For example, when an amino acid differs between a murine variable region framework residue and a selected human variable region framework residue, the human framework amino

acid can be substituted by the equivalent framework amino acid from the mouse antibody when it is reasonably expected that the amino acid:

(1) noncovalently binds antigen directly;

(2) is adjacent to a CDR region or within a CDR as defined by Chothia but not Kabat;

(3) otherwise interacts with a CDR region (*e.g.*, is within about 6 Å of a CDR region), (*e.g.*, identified by modeling the light or heavy chain on the solved structure of a homologous known immunoglobulin chain); or

(4) is a residue participating in the VL-VH interface.

[0216] The invention provides humanized forms of the murine 3D6 antibody including 7 exemplified humanized heavy chain mature variable regions (hu3D6VHvb1 (SEQ ID NO:76), hu3D6VHvb2 (SEQ ID NO:77), hu3D6VHvb3 (SEQ ID NO:78), hu3D6VHvb4 (SEQ ID NO:79), hu3D6VHvb5 (SEQ ID NO:80), hu3D6VHvb6 (SEQ ID NO:90), and hu3D6VHvb7 (SEQ ID NO:91)) and 3 exemplified humanized light chain mature variable regions (hu3D6VLvb1 (SEQ ID NO:83), hu3D6VLvb2 (SEQ ID NO:84), and hu3D6VLvb3 (SEQ ID NO:85)).

[0217] In an embodiment, humanized sequences are generated using a two-stage PCR protocol that allows introduction of multiple mutations, deletions, and insertions using QuikChange site-directed mutagenesis [Wang, W. and Malcolm, B.A. (1999) BioTechniques 26:680-682)].

[0218] Framework residues from classes (1) through (3) as defined by Queen, US 5,530,101, are sometimes alternately referred to as canonical and vernier residues. Framework residues that help define the conformation of a CDR loop are sometimes referred to as canonical residues (Chothia & Lesk, *J. Mol. Biol.* 196:901-917 (1987); Thornton & Martin, *J. Mol. Biol.* 263:800-815 (1996)). Framework residues that support antigen-binding loop conformations and play a role in fine-tuning the fit of an antibody to antigen are sometimes referred to as vernier residues (Foote & Winter, *J. Mol. Biol* 224:487-499 (1992)).

[0219] Other framework residues that are candidates for substitution are residues creating a potential glycosylation site. Still other candidates for substitution are acceptor human framework amino acids that are unusual for a human immunoglobulin at that position. These

amino acids can be substituted with amino acids from the equivalent position of the mouse donor antibody or from the equivalent positions of more typical human immunoglobulins.

[0220] Other framework residues that are candidates for substitution are N-terminal glutamine residues (Q) that may be replaced with glutamic acid (E) to minimize potential for pyroglutamate conversion [Y. Diana Liu, et al., 2011, J. Biol. Chem., 286: 11211–11217]. Glutamic acid (E) conversion to pyroglutamate (pE) occurs more slowly than from glutamine (Q). Because of the loss of a primary amine in the glutamine to pE conversion, antibodies become more acidic. Incomplete conversion produces heterogeneity in the antibody that can be observed as multiple peaks using charge-based analytical methods. Heterogeneity differences may indicate a lack of process control.

[0221] Exemplary humanized antibodies are humanized forms of the mouse 3D6, designated Hu3D6.

[0222] The mouse antibody 3D6 comprises mature heavy and light chain variable regions having amino acid sequences comprising SEQ ID NO:7 and SEQ ID NO:11, respectively. The invention provides 7 exemplified humanized mature heavy chain variable regions: hu3D6VHvb1, hu3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6VHvb5, hu3D6VHvb6, and hu3D6VHvb7. The invention further provides 3 exemplified mature light chain variable regions hu3D6VLvb1, hu3D6VLvb2, and hu3D6VLvb3. Figures 1 and 2 show alignments of the heavy chain variable region and light chain variable region, respectively, of murine 3D6 and various humanized antibodies.

[0223] For reasons such as possible influence on CDR conformation and/or binding to antigen, mediating interaction between heavy and light chains, interaction with the constant region, being a site for desired or undesired post-translational modification, being an unusual residue for its position in a human variable region sequence and therefore potentially immunogenic, getting aggregation potential, and other reasons, the following 31 variable region framework positions were considered as candidates for substitutions in the 3 exemplified human mature light chain variable regions and the 7 exemplified human mature heavy chain variable regions, as further specified in the examples: L7 (T7S, from germ line), L10 (T10S, from germ line), L15 (I15L, from germ line), L17 (Q17E, to enhance stability), L37 (L37Q, from germ line), L45 (K45R,

from germ line), L83 (L83V, from germ line), L86 (H86Y, from mouse 3D6), L100 (A100Q, from germ line), L106 (L106I, from germ line), H1 (Q1E, from mouse 3D6), H5 (Q5V, from germ line), H11 (L11V, from germ line), H17 (S17T, from germ line), H20 (L20I, from germ line), H23 (T23K, from germ line), H38 (K38R, from mouse 3D6), H42 (E42G, from germ line), H43 (Q43K, from germ line), H66 (K66R, from germ line), H67 (A67V, from germ line), H75 (S75T, from germ line , H76 (N76D, from germ line), H80 (L80M, from germ line), H81 (Q81E, from germ line), H83 (T83R, from germ line), H91 (Y91F, from mouse 3D6), H93 (A93S, from mouse 3D6), H94 (S94T, from mouse 3D6), H108 (T108L, from germ line), and H109 (L109V, from germ line). Here and elsewhere in describing substitutions, comments in parentheses indicate one rationale for a substitution. Some substitutions have multiple rationales. The following 5 variable region CDR positions were considered as candidates for substitutions in the 3 exemplified human mature light chain variable regions and 7 exemplified human mature heavy chain variable regions, as further specified in the examples: L24 (K24R, from germ line), H28 (N28T, from germ line), H54 (N54D, from germ line), H56 (D56E, from germline), and H58 (V58I, from germ line). In some humanized 3D6 antibodies, Kabat CDR-H2 has an amino acid sequence comprising SEQ ID NO:87. In some humanized 3D6 antibodies, Kabat-Chothia Composite CDR-H1 has an amino acid sequence comprising SEQ ID NO:86, and Kabat CDR-H2 has an amino acid sequence comprising SEQ ID NO:87. In some humanized 3D6 antibodies, Kabat-Chothia Composite CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and Kabat CDR-H2 has an amino acid sequence comprising SEQ ID NO:88. In some humanized 3D6 antibodies, Kabat-Chothia Composite CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and Kabat CDR-H2 has an amino acid sequence comprising SEQ ID NO:92. In some humanized 3D6 antibodies, Kabat CDR-L1 has an amino acid sequence comprising SEQ ID NO:89.

[0224] Here, as elsewhere, the first-mentioned residue is the residue of a humanized antibody formed by grafting Kabat CDRs or a composite Chothia-Kabat CDR in the case of CDR-H1 into a human acceptor framework, and the second-mentioned residue is a residue being considered for replacing such residue. Thus, within variable region frameworks, the first mentioned residue is human, and within CDRs, the first mentioned residue is mouse.

[0225] Exemplified antibodies include any permutations or combinations of the exemplified mature heavy and light chain variable regions VHvb1/VLvb1, VHvb1/VLvb2, VHvb1/VLvb3, VHvb2/VLvb1, VHvb2/VLvb2, VHvb2/VLvb3, VHvb3/VLvb1, VHvb3/VLvb2, VHvb3/VLvb3, VHvb4/VLvb1, VHvb4/VLvb2, VHvb4/VLvb3, VHvb5/VLvb1, VHvb5/VLvb2, VHvb5/VLvb3, VHvb6/VLvb1, VHvb6/VLvb2, VHvb6/VLvb3, VHvb7/VLvb1, VHvb7/VLvb2, VHvb7/VLvb3.

[0226] Exemplified antibodies include any permutations or combinations of the exemplified mature heavy chain variable regions hu3D6VHvb1 (SEQ ID NO:76), hu3D6VHvb2 (SEQ ID NO:77), hu3D6VHvb3 (SEQ ID NO:78), hu3D6VHvb4 (SEQ ID NO:79), hu3D6Hvb5 (SEQ ID NO:80), hu3D6VHvb6 (SEQ ID NO:90), and hu3D6VHvb7 (SEQ ID NO:91) with any of the humanized 3D6VL light chain variable regions hu3D6VLv1 (SEQ ID NO:20), hu3D6VLv2 (SEQ ID NO:21), hu3D6VLv3 (SEQ ID NO:22), and hu3D6VLv4 (SEQ ID NO:22). Exemplified antibodies include any permutations or combinations of the exemplified mature light chain variable regions hu3D6VLvb1 (SEQ ID NO:83), hu3D6VLvb2 (SEQ ID NO:84), or hu3D6VLvb3 (SEQ ID NO:85) with any of the humanized 3D6V6 heavy chain variable regions hu3D6VHv1 (SEQ ID NO:15); hu3D6VHv2 (SEQ ID NO:16); hu3D6VHv1b (SEQ ID NO:17); hu3D6VHv1bA11 (SEQ ID NO:18); hu3D6VHv5 (SEQ ID NO:19); hu3D6VHv1bA11B6G2 (SEQ ID NO:46); hu3D6VHv1bA11B6H3 (SEQ ID NO:47); hu3D6VHv1c (SEQ ID NO:48); hu3D6VHv1d (SEQ ID NO:49); hu3D6VHv1e (SEQ ID NO:50); hu3D6VHv1f (SEQ ID NO:51); hu3D6VHv3 (SEQ ID NO:52); hu3D6VHv3b (SEQ ID NO:53); hu3D6VHv3c (SEQ ID NO:54); hu3D6VHv4 (SEQ ID NO:55); hu3D6VHv4b (SEQ ID NO:56); and hu3D6VHv4c (SEQ ID NO:57).

[0227] The invention provides variants of the 3D6 humanized antibody in which the humanized mature heavy chain variable region shows at least 90%, 95%, 96%, 97%, 98%, or 99% identity to hu3D6VHvb1 (SEQ ID NO:76), hu3D6VHvb2 (SEQ ID NO:77), hu3D6VHvb3 (SEQ ID NO:78), hu3D6VHvb4 (SEQ ID NO:79), hu3D6Hvb5 (SEQ ID NO:80), hu3D6VHvb6 (SEQ ID NO:90), or hu3D6VHvb7 (SEQ ID NO:91) and the humanized mature light chain variable region shows at least 90%, 95%, 96%, 97%, 98%, or 99% identity to hu3D6VLvb1 (SEQ ID NO:83), hu3D6VLvb2 (SEQ ID NO:84), or hu3D6VLvb3 (SEQ ID NO:85). In some such antibodies at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,

23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, or all 36 of the backmutations or other mutations in SEQ ID NOs:76-80, SEQ ID NOs:90-91, and SEQ ID NOs:83-85) are retained. Some such humanized antibodies contain the same set of backmutations or other mutations as in the exemplified sequences defining sequence identity.

[0228] Thus for example, the invention includes humanized antibodies having a mature heavy chain variable region with at least 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to the mature heavy chain variable region of SEQ ID NO:77, and the same set of mutations as listed in Table 6 of SEQ ID NO:77, and three CDRs of SEQ ID NO:77, and a mature light chain region with at least 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to SEQ ID 84 or 85, and the same set of mutations as listed in Table 7 for SEQ ID NO:84 or 85 respectively, and three CDRs of SEQ ID NO:84 or 85 respectively. Some antibodies comprise a mature heavy chain variable region of SEQ ID NO:77 and a mature light chain variable region of SEQ ID NO:84 or 85.

[0229] The invention also includes humanized antibodies having a mature heavy chain variable region with at least 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to the mature heavy chain variable region of SEQ ID NO:90, and the same set of mutations as listed in Table 6 for SEQ ID NO:90, and three CDRs of SEQ ID NO:90, and a mature light chain region with at least 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to SEQ ID NO:84 or 85, and the same set of mutations as listed in Table 7 for SEQ ID NO:84 or 85 respectively, and three CDRs of SEQ ID NO:84 or 85 respectively. Some antibodies comprise a mature heavy chain variable region of SEQ ID NO:90 and a mature light chain variable region of SEQ ID NO:84 or 85.

[0230] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H93 is occupied by S and H94 is occupied by T. In some humanized 3D6 antibodies, positions H93 and H94 (Vernier residues) are occupied by S and T, respectively, as is the case in, e.g., huVHvb1, huVHvb2, huVHvb3, huVHvb4, huVHvb5, huVHvb6, and huVHvb7.

[0231] In some humanized 3D6 antibodies, position H91 (interface residue) in the VH region is occupied by F, as is the case in, e.g., huVHvb1, huVHvb2, and huVHvb6.

[0232] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by E, H5 is occupied by V, H11 is occupied by V, H20 is occupied I, H23 is occupied by K, H38 is occupied by R, H42 is occupied by G, H43 is occupied by K, H66 is occupied by R, H75 is occupied by T, H76 is occupied by D, H81 is occupied by E, H108 is occupied by L, H109 is occupied by V. In some humanized 3D6 antibodies, positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, L, and V, respectively, as is the case in, e.g., huVHvb2, huVHvb3, huVHvb4, huVHvb5, huVHvb6, and huVHvb7.

[0233] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H17 is occupied by T, H80 is occupied by M, H83 is occupied by R. In some humanized 3D6 antibodies, positions H17, H80, and H83 in the VH region are occupied by T, M, and R, respectively, as is the case in, e.g., huVHvb3, huVHvb4, huVHvb5, huVHvb6, and huVHvb7.

[0234] In some humanized 3D6 antibodies, position H58 (CDR-H2 residue) in the VH region is occupied by I, as is the case in, e.g., huVHvb3, huVHvb4, and huVHvb5.

[0235] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H28 is occupied by T, H67 is occupied by V. In some humanized 3D6 antibodies, positions H28 and H67 in the VH region are occupied by T and V, respectively, as is the case in e.g., in huVHvb4, huVHvb5, huVHvb6, and huVHvb7.

[0236] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H54 is occupied by D, H56 is occupied by E. In some humanized 3D6 antibodies, positions H54 and H56 (CDR-H2 residues) in the VH region are occupied by D and E, respectively, as is the case in, e.g., huVHvb6 and huVHvh7.

[0237] In some humanized 3D6 antibodies, at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by Q or E, H5 is occupied by Q or V, H11 is occupied by L or V , H17 is occupied by S or T, H20 is occupied by L or I, H23 is occupied by T or K, H28 is occupied by N or T, H38 is occupied by K or R, H42 is occupied by E or G, H43 is occupied by Q or K, H54 is occupied by N or D, H56 is occupied by D or E,

H58 is occupied by V or I, H66 is occupied by K or R, H67 is occupied by A or V, H75 is occupied by S or T, H76 is occupied by N or D, H80 is occupied by L or M, H81 is occupied by Q or E, H83 is occupied by T or R , H91 is occupied by F or Y, H93 is occupied by S, H94 is occupied by T, H108 is occupied by T or L, H109 is occupied by L or V.

[0238] In some humanized 3D6 antibodies, positions H91, H93, and H94 in the VH region are occupied by F, S, and T, respectively, as in huVHvb1. In some humanized 3D6 antibodies, positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, F, S, T,L, and V, respectively, as in huVHvb2. In some humanized 3D6 antibodies, positions H1, H5, H11, H17, H20, H23, H38, H42, H43, H58, H66, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, R, G, K, I, R, T, D, M, E, R, S, T, L, and V, respectively, as in huVHvb3. In some humanized 3D6 antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, I, R, V, T, D, M, E, R, S, T, L, and V, respectively, as in huVHvb4. In some humanized 3D6 antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, I, R, V, T, D, M, E, R, S, T, L, and V, respectively, as in huVHvb5. In some humanized 3D6 antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, F, S, T, L, and V, respectively, as in huVHvb6. In some humanized 3D6 antibodies, positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, S, T, L, and V, respectively, as in huVHvb7.

[0239] In some humanized 3D6 antibodies, at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is occupied by S, L10 is occupied by S, L15 is occupied by L, L83 is occupied by V, L86 is occupied by Y, and L106 is occupied by I. In some humanized 3D6 antibodies, positions L7, L10, L15, L83, L86, and L106 are occupied by S, S, L, V, Y, and Y, respectively, as is the case in, e.g., huVHvb2 and huVLvb3.

[0240] In some humanized 3D6 antibodies, at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is T or S, L10 is T or S, L15 is I or L, L17 is Q or E, L24 is K or R, L37 is L or Q, L45 is K or R, L83 is L or V, L86 is H or Y, L100 is A or Q, L106 is L or I.

[0241] In some humanized 3D6 antibodies, positions L7, L10, L15, L83, L86, and L106 in the VL region are occupied by S, S, L, V, Y, and I, respectively, as in huVLvb2. In some humanized 3D6 antibodies, positions L7, L10, L15, L17, L24, L37, L45, L83, L86, L100, and L106 in the VL region are occupied by S, S, L, E, R, Q, R, V, Y, Q, and I, respectively, as in huVLvb3.

[0242] In some humanized 3D6 antibodies, the variable heavy chain has ≥ 85% identity to human sequence. In some humanized 3D6 antibodies, the variable light chain has ≥ 85% identity to human sequence. In some humanized 3D6 antibodies, each of the variable heavy chain and variable light chain has ≥ 85% identity to human germline sequence. In some humanized 3D6 antibodies, the three heavy chain CDRs are as defined by Kabat/Chothia Composite (SEQ ID NOs:8, 9, and 10) and the three light chain CDRs are as defined by Kabat/Chothia Composite (SEQ ID NOs:12, 13, and 14); provided that position H28 is occupied by N or T, position H54 is occupied by N or D, position H56 is occupied by D or E, position H58 is occupied by V or I, and position L24 is occupied by K or R. In some humanized 3D6 antibodies, Kabat/Chothia Composite CDR-H1 has an amino acid sequence comprising SEQ ID NO:86. In some humanized 3D6 antibodies, Kabat CDR-H2 has an amino acid sequence comprising SEQ ID NO:87, SEQ ID NO:88, or SEQ ID NO:92. In some humanized 3D6 antibodies, Kabat CDR-L1 has an amino acid sequence comprising SEQ ID NO:89.

[0243] The CDR regions of such humanized antibodies can be identical or substantially identical to the CDR regions of 3D6, The CDR regions can be defined by any conventional definition (e.g., Chothia, or composite of Chothia and Kabat) but are preferably as defined by Kabat.

[0244] Variable regions framework positions are in accordance with Kabat numbering unless otherwise stated. Other such variants typically differ from the sequences of the exemplified Hu3D6 heavy and light chains by a small number (*e.g.*, typically no more than 1, 2, 3, 5, 10, or

15) of replacements, deletions or insertions. Such differences are usually in the framework but can also occur in the CDRs. ,

[0245] A possibility for additional variation in humanized 3D6 variants is additional backmutations in the variable region frameworks. Many of the framework residues not in contact with the CDRs in the humanized mAb can accommodate substitutions of amino acids from the corresponding positions of the donor mouse mAb or other mouse or human antibodies, and even many potential CDR-contact residues are also amenable to substitution. Even amino acids within the CDRs may be altered, for example, with residues found at the corresponding position of the human acceptor sequence used to supply variable region frameworks. In addition, alternate human acceptor sequences can be used, for example, for the heavy and/or light chain. If different acceptor sequences are used, one or more of the backmutations recommended above may not be performed because the corresponding donor and acceptor residues are already the same without backmutations.

[0246] Preferably, replacements or backmutations in humanized 3D6 variants (whether or not conservative) have no substantial effect on the binding affinity or potency of the humanized mAb, that is, its ability to bind to tau.

[0247] The humanized 3D6 antibodies are further characterized by their ability to bind both phosphorylated and unphosphorylated tau and misfolded/aggregated forms of tau. Some humanized antibodies are characterized by binding to human tau or possession of other functional property, such as inhibition of tau binding to neuronal cells or disaggregation of tau, the same as or more strongly than mouse 3D6 (e.g., up to 2x, 5x, 10x or 20x) that of mouse 3D6. Such properties can be compared by any of the assays described in the examples.

C. Selection of Constant Region

[0248] The heavy and light chain variable regions of chimeric, veneered or humanized antibodies can be linked to at least a portion of a human constant region. The choice of constant region depends, in part, whether antibody-dependent cell-mediated cytotoxicity, antibody dependent cellular phagocytosis and/or complement dependent cytotoxicity are desired. For example, human isotypes IgG1 and IgG3 have complement-dependent cytotoxicity and human isotypes IgG2 and IgG4 do not. Human IgG1 and IgG3 also induce stronger cell mediated

effector functions than human IgG2 and IgG4. Light chain constant regions can be lambda or kappa. Numbering conventions for constant regions include EU numbering (Edelman, G.M. et al., Proc. Natl. Acad. USA, 63, 78-85 (1969)), Kabat numbering (Kabat, *Sequences of Proteins of Immunological Interest* (National Institutes of Health, Bethesda, MD, 1991, IMGT unique numbering (Lefranc M.-P. et al., IMGT unique numbering for immunoglobulin and T cell receptor constant domains and Ig superfamily C-like domains, Dev. Comp. Immunol., 29, 185-203 (2005), and IMGT exon numbering (Lefranc, supra).

[0249] One or several amino acids at the amino or carboxy terminus of the light and/or heavy chain, such as the 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.

[0250] An exemplary human light chain kappa constant region has the amino acid sequence of SEQ ID NO: 104 (with or without the N-terminal arginine). An exemplary human IgG1 heavy chain constant region has the amino acid sequence of SEQ ID NO: 103 (with or without the C-

terminal lysine). Antibodies can be expressed as tetramers containing two light and two heavy chains, as separate heavy chains, light chains, as Fab, Fab', F(ab')2, and Fv, or as single chain antibodies in which heavy and light chain mature variable domains are linked through a spacer.

[0251] Human constant regions show allotypic variation and isoallotypic variation between different individuals, that is, the constant regions can differ in different individuals at one or more polymorphic positions. Isoallotypes differ from allotypes in that sera recognizing an isoallotype bind to a non-polymorphic region of a one or more other isotypes. Thus, for example, another heavy chain constant region is of IgG1 G1m3 with or without the C-terminal lysine. Reference to a human constant region includes a constant region with any natural allotype or any permutation of residues occupying positions in natural allotypes.

D. Expression of Recombinant Antibodies

[0252] A number of methods are known for producing chimeric and humanized antibodies using an antibody-expressing cell line (*e.g.*, hybridoma). For example, the immunoglobulin variable regions of antibodies can be cloned and sequenced using well known methods. In one method, the heavy chain variable VH region is cloned by RT-PCR using mRNA prepared from hybridoma cells. Consensus primers are employed to the VH region leader peptide encompassing the translation initiation codon as the 5' primer and a g2b constant regions specific 3' primer. Exemplary primers are described in U.S. patent publication US 2005/0009150 by Schenk *et al*. (hereinafter "Schenk"). The sequences from multiple, independently derived clones can be compared to ensure no changes are introduced during amplification. The sequence of the VH region can also be determined or confirmed by sequencing a VH fragment obtained by 5' RACE RT-PCR methodology and the 3' g2b specific primer.

[0253] The light chain variable VL region can be cloned in an analogous manner. In one approach, a consensus primer set is designed for amplification of VL regions using a 5' primer designed to hybridize to the VL region encompassing the translation initiation codon and a 3' primer specific for the Ck region downstream of the V-J joining region. In a second approach, 5'RACE RT-PCR methodology is employed to clone a VL encoding cDNA. Exemplary primers are described in Schenk, supra. The cloned sequences are then combined with sequences encoding human (or other non-human species) constant regions. Exemplary sequences encoding

human constant regions include SEQ ID NO:105, which encodes a human IgG1 constant region (SEQ ID NO:103), and SEQ ID NO:106, which encodes a human kappa light chain constant region (SEQ ID NO:104).

[0254] In one approach, the heavy and light chain variable regions are re-engineered to encode splice donor sequences downstream of the respective VDJ or VJ junctions and are cloned into a mammalian expression vector, such as pCMV-hγ1 for the heavy chain and pCMV-Mcl for the light chain. These vectors encode human γ1 and Ck constant regions as exonic fragments downstream of the inserted variable region cassette. Following sequence verification, the heavy chain and light chain expression vectors can be co-transfected into CHO cells to produce chimeric antibodies. Conditioned media is collected 48 hours post-transfection and assayed by western blot analysis for antibody production or ELISA for antigen binding. The chimeric antibodies are humanized as described above.

[0255] Chimeric, veneered, humanized, and human antibodies are typically produced by recombinant expression. Recombinant polynucleotide constructs typically include an expression control sequence operably linked to the coding sequences of antibody chains, including naturally associated or heterologous expression control elements, such as a promoter. The expression control sequences can be promoter systems in vectors capable of transforming or transfecting eukaryotic or prokaryotic 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 crossreacting antibodies.

[0256] 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 or hygromycin resistance, to permit detection of those cells transformed with the desired DNA sequences.

[0257] *E. coli* is one prokaryotic host useful for expressing antibodies, particularly antibody fragments. Microbes, such as yeast, are also useful for expression. *Saccharomyces* is a yeast host with suitable vectors having expression control sequences, 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.

[0258] Mammalian cells can be used for expressing nucleotide segments encoding immunoglobulins or fragments thereof. *See* Winnacker, From Genes to Clones, (VCH Publishers, NY, 1987). A number of suitable host cell lines capable of secreting intact heterologous proteins have been developed, and include CHO cell lines, various COS cell lines, HeLa cells, HEK293 cells, L cells, and non-antibody-producing myelomas including Sp2/0 and NS0. The cells can be nonhuman. Expression vectors for these cells can include expression control sequences, such as an origin of replication, a promoter, an enhancer (Queen *et al.*, *Immunol. Rev.* 89:49 (1986)), and necessary processing information sites, such as ribosome binding sites, RNA splice sites, polyadenylation sites, and transcriptional terminator sequences. Expression control sequences can include promoters derived from endogenous genes, cytomegalovirus, SV40, adenovirus, bovine papillomavirus, and the like. *See* Co *et al.*, *J. Immunol.* 148:1149 (1992).

[0259] Alternatively, 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 (*see, e.g.*, U.S. Pat. No. 5,741,957; U.S. Pat. No. 5,304,489; and U.S. Pat. No. 5,849,992). Suitable transgenes include coding sequences for light and/or heavy chains operably linked with a promoter and enhancer from a mammary gland specific gene, such as casein or beta lactoglobulin.

[0260] The vectors containing the DNA segments of interest can be transferred into the host cell by methods 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 can be used for other cellular hosts. Other methods used to transform mammalian cells include the use of polybrene, protoplast fusion, liposomes, electroporation, and microinjection. 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.

[0261] Having introduced vector(s) encoding antibody heavy and light chains into cell culture, cell pools can be screened for growth productivity and product quality in serum-free media. Top-producing cell pools can then be subjected of FACS-based single-cell cloning to generate monoclonal lines. Specific productivities above 50 pg or 100 pg per cell per day, which correspond to product titers of greater than 7.5 g/L culture, can be used. Antibodies produced by single cell clones can also be tested for turbidity, filtration properties, PAGE, IEF, UV scan, HP-SEC, carbohydrate-oligosaccharide mapping, mass spectrometry, and binding assay, such as ELISA or Biacore. A selected clone can then be banked in multiple vials and stored frozen for subsequent use.

[0262] Once expressed, antibodies can be purified according to standard procedures of the art, including protein A capture, HPLC purification, column chromatography, gel electrophoresis and the like (*see generally*, Scopes, *Protein Purification* (Springer-Verlag, NY, 1982)).

[0263] Methodology for commercial production of antibodies can be employed, including codon optimization, selection of promoters, selection of transcription elements, selection of terminators, serum-free single cell cloning, cell banking, use of selection markers for amplification of copy number, CHO terminator, or improvement of protein titers (*see, e.g.*, US 5,786,464; US 6,114,148; US 6,063,598; US 7,569,339; W02004/050884; W02008/012142; W02008/012142; W02005/019442; W02008/107388; W02009/027471; and US 5,888,809).

Antibodies can also be administered in the form of nucleic acids encoding the antibody heavy and/or light chains. If both heavy and light chains are present, the chains are preferably linked as a single chain antibody. Antibodies for passive administration can also be prepared *e.g.*, by affinity chromatography from sera of patients treated with peptide immunogens.

[0264] The DNA can be delivered in naked form (*i.e.*, without colloidal or encapsulating materials). Alternatively a number of viral vector systems can be used including retroviral systems (see, *e.g.*, Lawrie and Tumin, Cur. Opin. Genet. Develop. 3, 102-109 (1993)) including retrovirus derived vectors such MMLV, HIV-1, and ALV; adenoviral vectors {see, *e.g.*, Bett et al, J. Virol. 67, 591 1 (1993)); adeno-associated virus vectors {see, *e.g.*, Zhou et al., J. Exp. Med. 179, 1867 (1994)), lentiviral vectors such as those based on HIV or FIV gag sequences, viral vectors from the pox family including vaccinia virus and the avian pox viruses, viral vectors

from the alpha virus genus such as those derived from Sindbis and Semliki Forest Viruses (see, *e.g.*, Dubensky et al., J. Virol. 70, 508-519 (1996)), Venezuelan equine encephalitis virus (see US 5,643,576) and rhabdoviruses, such as vesicular stomatitis virus (see WO 96/34625)and papillomaviruses (Ohe et al., Human Gene Therapy 6, 325-333 (1995); Woo et al, WO 94/12629 and Xiao & Brandsma, Nucleic Acids. Res. 24, 2630-2622 (1996)).

[0265] DNA encoding an immunogen, or encoding the antibody heavy and/or light chains, or a vector containing the same, can be packaged into liposomes. Suitable lipids and related analogs are described by US 5,208,036, US 5,264,618, US 5,279,833, and US 5,283,185. Vectors and DNA encoding an immunogen, or encoding the antibody heavy and/or light chains can also be adsorbed to or associated with particulate carriers, examples of which include polymethyl methacrylate polymers and polylactides and poly(lactide-co-glycolides), (see, *e.g.*, McGee et al., J. Micro Encap. 1996).

[0266] Vectors or segments therefrom encoding the antibody heavy and/or light chains can be incorporated in cells ex vivo, for example to cells explanted from an individual patient (e.g., lymphocytes, bone marrow aspirates, tissue biopsy) or universal donor hematopoietic stem cells, followed by reimplantation of the cells into a patient, usually after selection for cells which have incorporated the transgenes. (see, e.g., WO 2017/091512). Exemplary patient-derived cells include patient derived induced pluripotent stem cells (iPSCs) or other types of stem cells (embryonic, hematopoietic, neural, or mesenchymal).

[0267] A vector or segment therefrom encoding the antibody heavy and/or light chains can be introduced into any region of interest in cells ex vivo, such as an albumin gene or other safe harbor gene. Cells incorporating the vector can be implanted with or without prior differentiation. Cells can be implanted into a specific tissue, such as a secretory tissue or a location of pathology, or systemically, such as by infusion into the blood. For example, cells can be implanted into a secretory tissue of a patient, such as the liver, optionally with prior differentiation to cells present in that tissue, such as hepatocytes in the case of a liver. Expression of the antibody in the liver results in secretion of the antibody to the blood.

E. Antibody Screening Assays

[0268] Antibodies can be initially screened for the intended binding specificity as described above. Active immunogens can likewise be screened for capacity to induce antibodies with such binding specificity. In this case, an active immunogen is used to immunize a laboratory animal and the resulting sera tested for the appropriate binding specificity.

[0269] Antibodies having the desired binding specificity can then be tested in cellular and animal models. The cells used for such screening are preferentially neuronal cells. A cellular model of tau pathology has been reported in which neuroblastoma cells are transfected with a four-repeat domain of tau, optionally with a mutation associated with tau pathology (*e.g.*, delta K280, see Khlistunova, Current Alzheimer Research 4, 544-546 (2007)). In another model, tau is induced in the neuroblastoma N2a cell line by the addition of doxycyclin. The cell models enable one to study the toxicity of tau to cells in the soluble or aggregated state, the appearance of tau aggregates after switching on tau gene expression, the dissolution of tau aggregates after switching the gene expression off again, and the efficiency of antibodies in inhibiting formation of tau aggregates or disaggregating them.

[0270] Antibodies can also be screened in transgenic animal models of diseases associated with tau. Such transgenic animals can include a tau transgene (*e.g.*, any of the human isoforms) and optionally a human APP transgene among others, such as a kinase that phosphorylates tau, ApoE, presenilin or alpha synuclein. Such transgenic animals are disposed to develop at least one sign or symptom of a disease associated with tau.

[0271] An exemplary transgenic animal is the K3 line of mice (Itner et al., Proc. Natl. Acad. Sci. USA 105(41):15997-6002 (2008)). These mice have a human tau transgene with a K 369 I mutation (the mutation is associated with Pick's disease) and a Thy 1.2 promoter. This model shows a rapid course of neurodegeneration, motor deficit and degeneration of afferent fibers and cerebellar granule cells. Another exemplary animal is the JNPL3 line of mice. These mice have a human tau transgene with a P301L mutation (the mutation is associated with frontotemporal dementia) and a Thy 1.2 promoter (Taconic, Germantown, N.Y., Lewis, et al., Nat Genet. 25:402-405 (2000)). These mice have a more gradual course of neurodegeneration. The mice develop neurofibrillary tangles in several brain regions and spinal cord, which is hereby

incorporated by reference in its entirety). This is an excellent model to study the consequences of tangle development and for screening therapy that may inhibit the generation of these aggregates. Another advantage of these animals is the relatively early onset of pathology. In the homozygous line, behavioral abnormalities associated with tau pathology can be observed at least as early as 3 months, but the animals remain relatively healthy at least until 8 months of age. In other words, at 8 months, the animals ambulate, feed themselves, and can perform the behavioral tasks sufficiently well to allow the treatment effect to be monitored. Active immunization of these mice for 6-13 months with - AI wI KLH-PHF-1 generated titers of about 1,000 and showed fewer neurofibrillary tangles, less pSer422, and reduced weight loss relative to untreated control mice.

[0272] The activity of antibodies can be assessed by various criteria including reduction in amount of total tau or phosphorylated tau, reduction in other pathological characteristics, such as amyloid deposits of Aβ, and inhibition or delay or behavioral deficits. Antibodies can be tested for passage of antibodies across the blood brain barrier into the brain of a transgenic animal. Antibodies or fragments inducing an antibody can also be tested in non-human primates that naturally or through induction develop symptoms of diseases characterized by tau. Tests on an antibody are usually performed in conjunction with a control in which a parallel experiment is conduct except that the antibody or active agent is absent (*e.g.*, replaced by vehicle). Reduction, delay or inhibition of signs or symptoms disease attributable to an antibody or active agent under test can then be assessed relative to the control.

IV. Patients Amenable to Treatment

[0273] The presence of neurofibrillary tangles has been found in several diseases including Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), and

progressive supranuclear palsy (PSP). The present regimes can also be used in treatment or prophylaxis of any of these diseases. Because of the widespread association between neurological diseases and conditions and tau, the present regimes can be used in treatment or prophylaxis of any subject showing elevated levels of tau or phosphorylated tau (*e.g.*, in the CSF) compared with a mean value in individuals without neurological disease. The present regimes can also be used in treatment or prophylaxis of neurological disease in individuals having a mutation in tau associated with neurological disease. The present methods are particularly suitable for treatment or prophylaxis of Alzheimer's disease, and especially in patients.

[0274] Patients amenable to treatment include individuals at risk of disease but not showing symptoms, as well as patients presently showing symptoms. Patients at risk of disease include those having a known genetic risk of 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 include mutations in tau, such as those discussed above, as well as mutations in other genes associated with neurological disease. For example, the ApoE4 allele in heterozygous and even more so in homozygous form is associated with risk of Alzheimer's disease. Other markers of risk of 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, mutations in the presenilin genes, PS1 and PS2, a family history of AD, hypercholesterolemia or atherosclerosis. Individuals presently suffering from Alzheimer's disease can be recognized by PET imaging, 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 or phospho-tau and Aβ42 levels. Elevated tau or phospho-tau and decreased Aβ42 levels signify the presence of AD. Some mutations associated with Parkinson's disease. Ala30Pro or Ala53, or mutations in other genes associated with Parkinson's disease such as leucine-rich repeat kinase, PARK8. Individuals can also be diagnosed with any of the neurological diseases mentioned above by the criteria of the DSM IV TR.

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

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

V. Nucleic Acids

[0276] The invention further provides nucleic acids encoding any of the heavy and light chains described above (*e.g.*, SEQ ID NO:7, SEQ ID NO:11, SEQ ID NOs:76-80, SEQ ID NOs:90-91, and SEQ ID NOs:83-85). Exemplary nucleic acids include SEQ ID NOs: 30-31, 93-99, 100-102, and 105-106. Optionally, such nucleic acids further encode a signal peptide and can be expressed with the signal peptide linked to the heavy chain variable region or to the light chain variable region. Coding sequences of nucleic acids can be operably linked with regulatory sequences to ensure expression of the coding sequences, such as a promoter, enhancer, ribosome binding site, transcription termination signal, and the like. The regulatory sequences can include a promoter, for example, a prokaryotic promoter or a eukaryotic promoter. The nucleic acids encoding heavy or light chains can be codon-optimized for expression in a host cell. The nucleic acids encoding heavy and light chains can encode a selectable gene. The nucleic acids encoding heavy and light chains can occur in isolated form or can be cloned into one or more vectors. The nucleic acids can be synthesized by, for example, solid state synthesis or PCR of overlapping oligonucleotides. Nucleic acids encoding heavy and light chains can be joined as one contiguous nucleic acid, e.g., within an expression vector, or can be separate, e.g., each cloned into its own expression vector.

VI. Conjugated Antibodies

[0277] Conjugated antibodies that specifically bind to antigens, such as tau, are useful in detecting the presence of tau; monitoring and evaluating the efficacy of therapeutic agents being used to treat patients diagnosed with Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam,

corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP); inhibiting or reducing aggregation of tau; inhibiting or reducing tau fibril formation; reducing or clearing tau deposits; stabilizing non-toxic conformations of tau; or treating or effecting prophylaxis of Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP) in a patient. For example, such antibodies can be conjugated with other therapeutic moieties, other proteins, other antibodies, and/or detectable labels. *See* WO 03/057838; US 8,455,622. Such therapeutic moieties can be any agent that can be used to treat, combat, ameliorate, prevent, or improve an unwanted condition or disease in a patient, such as Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP) in a patient. For example, such antibodies can be conjugated with other therapeutic moieties, other proteins, other antibodies, and/or detectable labels. *See* WO 03/057838; US 8,455,622. Such therapeutic moieties can be any agent that can be used to treat, combat, ameliorate, prevent, or improve an unwanted condition or disease in a patient, such as Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

[0278] Conjugated therapeutic moieties can include cytotoxic agents, cytostatic agents, neurotrophic agents, neuroprotective agents, radiotherapeutic agents, immunomodulators, or any biologically active agents that facilitate or enhance the activity of the antibody. A cytotoxic agent can be any agent that is toxic to a cell. A cytostatic agent can be any agent that inhibits cell proliferation. A neurotrophic agent can be any agent, including chemical or proteinaceous agents, that promotes neuron maintenance, growth, or differentiation. A neuroprotective agent can be agent, including chemical or proteinaceous agents, that protects neurons from acute insult

or degenerative processes. An immunomodulator can be any agent that stimulates or inhibits the development or maintenance of an immunologic response. A radiotherapeutic agent can be any molecule or compound that emits radiation. If such therapeutic moieties are coupled to a tau-specific antibody, such as the antibodies described herein, the coupled therapeutic moieties will have a specific affinity for tau-related disease-affected cells over normal cells. Consequently, administration of the conjugated antibodies directly targets cancer cells with minimal damage to surrounding normal, healthy tissue. This can be particularly useful for therapeutic moieties that are too toxic to be administered on their own. In addition, smaller quantities of the therapeutic moieties can be used.

[0279] Some such antibodies can be modified to act as immunotoxins. *See, e.g.*, U.S. Patent No. 5,194,594. For example, ricin, a cellular toxin derived from plants, can be coupled to antibodies by using the bifunctional reagents S-acetylmercaptosuccinic anhydride for the antibody and succinimidyl 3-(2-pyridyldithio)propionate for ricin. *See* Pietersz *et al.*, *Cancer Res.* 48(16):4469-4476 (1998). The coupling results in loss of B-chain binding activity of ricin, while impairing neither the toxic potential of the A-chain of ricin nor the activity of the antibody. Similarly, saporin, an inhibitor of ribosomal assembly, can be coupled to antibodies via a disulfide bond between chemically inserted sulfhydryl groups. *See* Polito *et al.*, *Leukemia* 18:1215-1222 (2004).

[0280] Some such antibodies can be linked to radioisotopes. Examples of radioisotopes include, for example, yttrium^{90} (90Y), indium^{111} (111In), ^{131}I, ^{99}mTc, radiosilver-111, radiosilver-199, and Bismuth^{213}. Linkage of radioisotopes to antibodies may be performed with conventional bifunction chelates. For radiosilver-111 and radiosilver-199 linkage, sulfur-based linkers may be used. *See* Hazra *et al.*, *Cell Biophys.* 24-25:1-7 (1994). Linkage of silver radioisotopes may involve reducing the immunoglobulin with ascorbic acid. For radioisotopes such as 111In and 90Y, ibritumomab tiuxetan can be used and will react with such isotopes to form 111In-ibritumomab tiuxetan and 90Y-ibritumomab tiuxetan, respectively. *See* Witzig, *Cancer Chemother. Pharmacol.*, 48 Suppl 1:S91-S95 (2001).

[0281] Some such antibodies can be linked to other therapeutic moieties. Such therapeutic moieties can be, for example, cytotoxic, cytostatic, neurotrophic, or neuroprotective. For

example, antibodies can be conjugated with toxic chemotherapeutic drugs such as maytansine, geldanamycin, tubulin inhibitors such as tubulin binding agents (*e.g.*, auristatins), or minor groove binding agents such as calicheamicin. Other representative therapeutic moieties include agents known to be useful for treatment, management, or amelioration of Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

[0282] Antibodies can also be coupled with other proteins. For example, antibodies can be coupled with Fynomers. Fynomers are small binding proteins (*e.g.*, 7 kDa) derived from the human Fyn SH3 domain. They can be stable and soluble, and they can lack cysteine residues and disulfide bonds. Fynomers can be engineered to bind to target molecules with the same affinity and specificity as antibodies. They are suitable for creating multi-specific fusion proteins based on antibodies. For example, Fynomers can be fused to N-terminal and/or C-terminal ends of antibodies to create bi- and tri-specific FynomAbs with different architectures. Fynomers can be selected using Fynomer libraries through screening technologies using FACS, Biacore, and cell-based assays that allow efficient selection of Fynomers with optimal properties. Examples of Fynomers are disclosed in Grabulovski *et al.*, *J. Biol. Chem.* 282:3196-3204 (2007); Bertschinger *et al.*, *Protein Eng. Des. Sel.* 20:57-68 (2007); Schlatter *et al.*, *MAbs.* 4:497-508 (2011); Banner *et al.*, *Acta. Crystallogr. D. Biol. Crystallogr.* 69(Pt6):1124-1137 (2013); and Brack *et al.*, *Mol. Cancer Ther.* 13:2030-2039 (2014).

[0283] The antibodies disclosed herein can also be coupled or conjugated to one or more other antibodies (*e.g.*, to form antibody heteroconjugates). Such other antibodies can bind to different epitopes within tau or can bind to a different target antigen.

[0284] Antibodies can also be coupled with a detectable label. Such antibodies can be used, for example, for diagnosing Alzheimer's disease, Down's syndrome, mild cognitive impairment,

primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP), and/or for assessing efficacy of treatment. Such antibodies are particularly useful for performing such determinations in subjects having or being susceptible to Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP), or in appropriate biological samples obtained from such subjects. Representative detectable labels that may be coupled or linked to an antibody include various enzymes, such as horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; prosthetic groups, such streptavidin/biotin and avidin/biotin; fluorescent materials, such as umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; luminescent materials, such as luminol; bioluminescent materials, such as luciferase, luciferin, and aequorin; radioactive materials, such as radiosilver-111, radiosilver-199, Bismuth^{213}, iodine (^{131}I, ^{125}I, ^{123}I, ^{121}I,), carbon (^{14}C), sulfur (^{5}S), tritium (^{3}H), indium (^{115}In, ^{113}In, ^{112}In, ^{111}In,), technetium (^{99}Tc), thallium (^{201}Ti), gallium (^{68}Ga, ^{67}Ga), palladium (^{103}Pd), molybdenum (^{99}Mo), xenon (^{133}Xe), fluorine (^{18}F), ^{153}Sm, ^{177}Lu, ^{159}Gd, ^{149}Pm, ^{140}La, ^{175}Yb, ^{166}Ho, ^{90}Y, ^{47}Sc, ^{186}Re, ^{188}Re, ^{142}Pr, ^{105}Rh, ^{97}Ru, ^{68}Ge, ^{57}Co, ^{65}Zn, ^{85}Sr, ^{32}P, ^{153}Gd, ^{169}Yb, ^{51}Cr, ^{54}Mn, ^{75}Se, ^{113}Sn, and ^{117}Tin; positron emitting metals using various positron emission tomographies; nonradioactive paramagnetic metal ions; and molecules that are radiolabelled or conjugated to specific radioisotopes.

[0285] Linkage of radioisotopes to antibodies may be performed with conventional bifunction chelates. For radiosilver-111 and radiosilver-199 linkage, sulfur-based linkers may be used. *See* Hazra *et al.*, *Cell Biophys.* 24-25:1-7 (1994). Linkage of silver radioisotopes may involve reducing the immunoglobulin with ascorbic acid. For radioisotopes such as 111In and 90Y, ibritumomab tiuxetan can be used and will react with such isotopes to form 111In-ibritumomab tiuxetan and 90Y-ibritumomab tiuxetan, respectively. *See* Witzig, *Cancer Chemother. Pharmacol.*, 48 Suppl 1:S91-S95 (2001).

[0286] Therapeutic moieties, other proteins, other antibodies, and/or detectable labels may be coupled or conjugated, directly or indirectly through an intermediate (*e.g.*, a linker), to an antibody of the invention. *See e.g.*, Arnon *et al.*, "Monoclonal Antibodies For Immunotargeting Of Drugs In Cancer Therapy," in Monoclonal Antibodies And Cancer Therapy, Reisfeld *et al.* (eds.), pp. 243-56 (Alan R. Liss, Inc. 1985); Hellstrom *et al.*, "Antibodies For Drug Delivery," in Controlled Drug Delivery (2nd Ed.), Robinson *et al.* (eds.), pp. 623-53 (Marcel Dekker, Inc. 1987); Thorpe, "Antibody Carriers Of Cytotoxic Agents In Cancer Therapy: A Review," in Monoclonal Antibodies 84: Biological And Clinical Applications, Pinchera *et al.* (eds.), pp. 475-506 (1985); "Analysis, Results, And Future Prospective Of The Therapeutic Use Of Radiolabeled Antibody In Cancer Therapy," in Monoclonal Antibodies For Cancer Detection And Therapy, Baldwin *et al.* (eds.), pp. 303-16 (Academic Press 1985); and Thorpe *et al.*, *Immunol. Rev.*, 62:119-58 (1982). Suitable linkers include, for example, cleavable and non-cleavable linkers. Different linkers that release the coupled therapeutic moieties, proteins, antibodies, and/or detectable labels under acidic or reducing conditions, on exposure to specific proteases, or under other defined conditions can be employed.

VII. Pharmaceutical Compositions and Methods of Use

[0287] In prophylactic applications, an antibody or a pharmaceutical composition the same is administered to a patient susceptible to, or otherwise at risk of a disease (*e.g.*, Alzheimer's disease) in regime (dose, frequency and route of administration) effective to reduce the risk, lessen the severity, or delay the onset of at least one sign or symptom of the disease. In particular, the regime is preferably effective to inhibit or delay tau or phospho-tau and paired filaments formed from it in the brain, and/or inhibit or delay its toxic effects and/or inhibit/or

delay development of behavioral deficits. In therapeutic applications, an antibody is administered to a patient suspected of, or already suffering from a disease (*e.g.*, Alzheimer's disease) in a regime (dose, frequency and route of administration) effective to ameliorate or at least inhibit further deterioration of at least one sign or symptom of the disease. In particular, the regime is preferably effective to reduce or at least inhibit further increase of levels of tau, phosphor-tau, or paired filaments formed from it , associated toxicities and/or behavioral deficits.

[0288] A regime is considered therapeutically or prophylactically effective if an individual treated patient achieves an outcome more favorable than the mean outcome in a control population of comparable patients not treated by methods of the invention, or if a more favorable outcome is demonstrated in treated patients versus control patients in a controlled clinical trial (*e.g.*, a phase II, phase II/III or phase III trial) at the $p < 0.05$ or 0.01 or even 0.001 level.

[0289] Effective doses of vary depending on many different factors, such as means of administration, target site, physiological state of the patient, whether the patient is an ApoE carrier, whether the patient is human or an animal, other medications administered, and whether treatment is prophylactic or therapeutic.

[0290] Exemplary dosage ranges for antibodies are from about 0.01 to 60 mg/kg, or from about 0.1 to 3 mg/kg or 0.15-2 mg/kg or 0.15-1.5 mg/kg, of patient body weight. Antibody can be administered such doses daily, on alternative days, weekly, fortnightly, monthly, quarterly, or according to any other schedule determined by empirical analysis. An exemplary treatment entails administration in multiple dosages over a prolonged period, for example, of at least six months. Additional exemplary treatment regimes entail administration once per every two weeks or once a month or once every 3 to 6 months.

[0291] Antibodies are preferably administered via a peripheral route (*i.e.*, one in which an administered or induced antibody crosses the blood brain barrier to reach an intended site in the brain. Routes of administration include topical, intravenous, oral, subcutaneous, intraarterial, intracranial, intrathecal, intraperitoneal, intranasal, intraocular, or intramuscular. Preferred routes for administration of antibodies are intravenous and subcutaneous. Preferred routes for active immunization are subcutaneous and intramuscular. This type of 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.

[0292] Pharmaceutical compositions for parenteral administration are preferably sterile and substantially isotonic and manufactured under GMP conditions. Pharmaceutical compositions can be provided in unit dosage form (*i.e.*, the dosage for a single administration). Pharmaceutical compositions can be formulated using one or more physiologically acceptable carriers, diluents, excipients or auxiliaries. The formulation depends on the route of administration chosen. For injection, antibodies can be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hank's solution, Ringer's solution, or physiological saline or acetate buffer (to reduce discomfort at the site of injection). The solution can contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Alternatively antibodies can be in lyophilized form for constitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water, before use.

[0293] The present regimes can be administered in combination with another agent effective in treatment or prophylaxis of the disease being treated. For example, in the case of Alzheimer's disease, the present regimes can be combined with immunotherapy against Aβ (WO/2000/072880), cholinesterase inhibitors or memantine or in the case of Parkinson's disease immunotherapy against alpha synuclein WO/2008/103472, Levodopa, dopamine agonists, COMT inhibitors, MAO-B inhibitors, Amantadine, or anticholinergic agents.

[0294] Antibodies are administered in an effective regime meaning a dosage, route of administration and frequency of administration that delays the onset, reduces the severity, inhibits further deterioration, and/or ameliorates at least one sign or symptom of a disorder being treated. If a patient is already suffering from a disorder, the regime can be referred to as a therapeutically effective regime. If the patient is at elevated risk of the disorder relative to the general population but is not yet experiencing symptoms, the regime can be referred to as a prophylactically effective regime. In some instances, therapeutic or prophylactic efficacy can be observed in an individual patient relative to historical controls or past experience in the same patient. In other instances, therapeutic or prophylactic efficacy can be demonstrated in a

preclinical or clinical trial in a population of treated patients relative to a control population of untreated patients.

[0295] Exemplary dosages for an antibody are 0.1-60 mg/kg (e.g., 0.5, 3, 10, 30, or 60 mg/kg), or 0.5-5 mg/kg body weight (e.g., 0.5, 1, 2, 3, 4 or 5 mg/kg) or 10-4000 mg or 10-1500 mg as a fixed dosage. The dosage depends on the condition of the patient and response to prior treatment, if any, whether the treatment is prophylactic or therapeutic and whether the disorder is acute or chronic, among other factors.

[0296] Administration can be parenteral, intravenous, oral, subcutaneous, intra-arterial, intracranial, intrathecal, intraperitoneal, topical, intranasal or intramuscular. Some antibodies can be administered into the systemic circulation by intravenous or subcutaneous administration. Intravenous administration can be, for example, by infusion over a period such as 30-90 min.

[0297] The frequency of administration depends on the half-life of the antibody in the circulation, the condition of the patient and the route of administration among other factors. The frequency can be daily, weekly, monthly, quarterly, or at irregular intervals in response to changes in the patient's condition or progression of the disorder being treated. An exemplary frequency for intravenous administration is between weekly and quarterly over a continuous cause of treatment, although more or less frequent dosing is also possible. For subcutaneous administration, an exemplary dosing frequency is daily to monthly, although more or less frequent dosing is also possible.

[0298] The number of dosages administered depends on whether the disorder is acute or chronic and the response of the disorder to the treatment. For acute disorders or acute exacerbations of a chronic disorder, between 1 and 10 doses are often sufficient. Sometimes a single bolus dose, optionally in divided form, is sufficient for an acute disorder or acute exacerbation of a chronic disorder. Treatment can be repeated for recurrence of an acute disorder or acute exacerbation. For chronic disorders, an antibody can be administered at regular intervals, *e.g.*, weekly, fortnightly, monthly, quarterly, every six months for at least 1, 5 or 10 years, or the life of the patient.

A. Diagnostics and Monitoring Methods

In Vivo Imaging, Diagnostic Methods, and Optimizing Immunotherapy

[0299] The invention provides methods of in vivo imaging tau protein deposits (*e.g.*, neurofibrillary tangles and tau inclusions) in a patient. The methods work by administering a a humanized antibody of the invention to the patient and then detecting the antibody after it has bound. A clearing response to the administered antibodies can be avoided or reduced by using antibody fragments lacking a full-length constant region, such as Fabs. In some methods, the same antibody can serve as both a treatment and diagnostic reagent.

[0300] Diagnostic reagents can be administered by intravenous injection into the body of the patient, or directly into the brain by intracranial injection or by drilling a hole through the skull. The dosage of reagent should be within the same ranges as for treatment methods. Typically, the reagent is labeled, although in some methods, the primary reagent with affinity for tau is unlabeled and a secondary labeling agent is used to bind to the primary reagent. The choice of label depends on the means of detection. For example, a fluorescent label is suitable for optical detection. Use of paramagnetic labels is suitable for tomographic detection without surgical intervention. Radioactive labels can also be detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).

[0301] The methods of in vivo imaging of tau protein deposits are useful to diagnose or confirm diagnosis of a tauopathy, such as Alzheimer's disease, frontotemporal lobar degeneration, progressive supranuclear palsy and Pick's disease, or susceptibility to such a disease. For example, the methods can be used on a patient presenting with symptoms of dementia. If the patient has abnormal neurofibrillary tangles, then the patient is likely suffering from Alzheimer's disease. Alternatively, if the patient has abnormal tau inclusions, then depending on the location of the inclusions, the patient may be suffering from frontotemporal lobar degeneration. The methods can also be used on asymptomatic patients. Presence of abnormal tau protein deposits indicates susceptibility to future symptomatic disease. The methods are also useful for monitoring disease progression and/or response to treatment in patients who have been previously diagnosed with a tau-related disease.

[0302] Diagnosis can be performed by comparing the number, size, and/or intensity of labeled loci, to corresponding baseline values. The base line values can represent the mean levels in a population of undiseased individuals. Baseline values can also represent previous levels

determined in the same patient. For example, baseline values can be determined in a patient before beginning tau immunotherapy treatment, and measured values thereafter compared with the baseline values. A decrease in values relative to baseline signals a positive response to treatment.

[0303] In some patients, diagnosis of a tauopathy may be aided by performing a PET scan. A PET scan can be performed using, for example, a conventional PET imager and auxiliary equipment. The scan typically includes one or more regions of the brain known in general to be associated with tau protein deposits and one or more regions in which few if any deposits are generally present to serve as controls.

[0304] The signal detected in a PET scan can be represented as a multidimensional image. The multidimensional image can be in two dimensions representing a cross-section through the brain, in three dimensions, representing the three dimensional brain, or in four dimensions representing changes in the three dimensional brain over time. A color scale can be used with different colors indicating different amounts of label and, inferentially, tau protein deposit detected. The results of the scan can also be presented numerically, with numbers relating to the amount of label detected and consequently amount of tau protein deposits. The label present in a region of the brain known to be associated with deposits for a particular tauopathy (*e.g.*, Alzheimer's disease) can be compared with the label present in a region known not to be associated with deposits to provide a ratio indicative of the extent of deposits within the former region. For the same radiolabeled ligand, such ratios provide a comparable measure of tau protein deposits and changes thereof between different patients.

[0305] In some methods, a PET scan is performed concurrent with or in the same patient visit as an MRI or CAT scan. An MRI or CAT scan provides more anatomical detail of the brain than a PET scan. However, the image from a PET scan can be superimposed on an MRI or CAT scan image more precisely indicating the location of PET ligand and inferentially tau deposits relative to anatomical structures in the brain. Some machines can perform both PET scanning and MRI or CAT scanning without the patient changing positions between the scans facilitating superimposition of images.

[0306] Suitable PET ligands include radiolabeled antibodies of the invention (*e.g.*, a mouse, humanized, chimeric or veneered 3D6 antibody). The radioisotope used can be, for example, C^{11}, N^{13}, O^{15}, F^{18}, or I^{123}. The interval between administering the PET ligand and performing the scan can depend on the PET ligand and particularly its rate of uptake and clearing into the brain, and the half- life of its radiolabel.

[0307] PET scans can also be performed as a prophylactic measure in asymptomatic patients or in patients who have symptoms of mild cognitive impairment but have not yet been diagnosed with a tauopathy but are at elevated risk of developing a tauopathy. For asymptomatic patients, scans are particularly useful for individuals considered at elevated risk of tauopathy because of a family history, genetic or biochemical risk factors, or mature age. Prophylactic scans can commence for example, at a patient age between 45 and 75 years. In some patients, a first scan is performed at age 50 years.

[0308] Prophylactic scans can be performed at intervals of for example, between six months and ten years, preferably between 1-5 years. In some patients, prophylactic scans are performed annually. If a PET scan performed as a prophylactic measure indicates abnormally high levels of tau protein deposits, immunotherapy can be commenced and subsequent PET scans performed as in patients diagnosed with a tauopathy. If a PET scanned performed as a prophylactic measure indicates levels of tau protein deposits within normal levels, further PET scans can performed at intervals of between six months and 10 years, and preferably 1-5 years, as before, or in response to appearance of signs and symptoms of a tauopathy or mild cognitive impairment. By combining prophylactic scans with administration of tau-directed immunotherapy if and when an above normal level of tau protein deposits is detected, levels of tau protein deposits can be reduced to, or closer to, normal levels, or at least inhibited from increasing further, and the patient can remain free of the tauopathy for a longer period than if not receiving prophylactic scans and tau-directed immunotherapy (*e.g.*, at least 5, 10, 15 or 20 years, or for the rest of the patient's life).

[0309] Normal levels of tau protein deposits can be determined by the amount of neurofibrillary tangles or tau inclusions in the brains of a representative sample of individuals in the general population who have not been diagnosed with a particular tauopathy (*e.g.*,

Alzheimer's disease) and are not considered at elevated risk of developing such disease (*e.g.*, a representative sample of disease-free individuals under 50 years of age). Alternatively, a normal level can be recognized in an individual patient if the PET signal according to the present methods in a region of the brain in which tau protein deposits are known to develop is not different (within the accuracy of measurement) from the signal from a region of the brain in which it is known that such deposits do not normally develop. An elevated level in an individual can be recognized by comparison to the normal levels (*e.g.*, outside mean and variance of a standard deviation) or simply from an elevated signal beyond experimental error in a region of the brain associated with tau protein deposits compared with a region not known to be associated with deposits. For purposes of comparing the levels of tau protein deposits in an individual and population, the tau protein deposits should preferably be determined in the same region(s) of the brain, these regions including at least one region in which tau protein deposits associated with a particular tauopathy (*e.g.*, Alzheimer's disease) are known to form. A patient having an elevated level of tau protein deposits is a candidate for commencing immunotherapy.

[0310] After commencing immunotherapy, a decrease in the level of tau protein deposits can be first seen as an indication that the treatment is having the desired effect. The observed decrease can be, for example, in the range of 1-100%, 1-50%, or 1-25% of the baseline value. Such effects can be measured in one or more regions of the brain in which deposits are known to form or can be measured from an average of such regions. The total effect of treatment can be approximated by adding the percentage reduction relative to baseline to the increase in tau protein deposits that would otherwise occur in an average untreated patient.

[0311] Maintenance of tau protein deposits at an approximately constant level or even a small increase in tau protein deposits can also be an indication of response to treatment albeit a suboptimal response. Such responses can be compared with a time course of levels of tau protein deposits in patients with a particular tauopathy (*e.g.*, Alzheimer's disease) that did not receive treatment, to determine whether the immunotherapy is having an effect in inhibiting further increases of tau protein deposits.

[0312] Monitoring of changes in tau protein deposits allows adjustment of the immunotherapy or other treatment regime in response to the treatment. PET monitoring provides an indication of

the nature and extent of response to treatment. Then a determination can be made whether to adjust treatment and if desired treatment can be adjusted in response to the PET monitoring. PET monitoring thus allows for tau-directed immunotherapy or other treatment regime to be adjusted before other biomarkers, MRI or cognitive measures have detectably responded. A significant change means that comparison of the value of a parameter after treatment relative to basement provides some evidence that treatment has or has not resulted in a beneficial effect. In some instances, a change of values of a parameter in a patient itself provides evidence that treatment has or has not resulted in a beneficial effect. In other instances, the change of values, if any, in a patient, is compared with the change of values, if any, in a representative control population of patients not undergoing immunotherapy. A difference in response in a particular patient from the normal response in the control patient (*e.g.*, mean plus variance of a standard deviation) can also provide evidence that an immunotherapy regime is or is not achieving a beneficial effect in a patient.

[0313] In some patients, monitoring indicates a detectable decline in tau protein deposits but that the level of tau protein deposits remains above normal. In such patients, if there are no unacceptable side effects, the treatment regime can be continued as is or even increased in frequency of administration and/or dose if not already at the maximum recommended dose.

[0314] If the monitoring indicates levels of tau protein deposits in a patient have already been reduced to normal, or near-normal, levels of tau protein deposits, the immunotherapy regime can be adjusted from one of induction (*i.e.*, that reduces the level of tau protein deposits) to one of maintenance (*i.e.* , that maintains tau protein deposits at an approximately constant level). Such a regime can be affected by reducing the dose and or frequency of administering immunotherapy.

[0315] In other patients, monitoring can indicate that immunotherapy is having some beneficial effect but a suboptimal effect. An optimal effect can be defined as a percentage reduction in the level of tau protein deposits within the top half or quartile of the change in tau protein deposits (measured or calculated over the whole brain or representative region(s) thereof in which tau protein deposits are known to form) experienced by a representative sample of tauopathy patients undergoing immunotherapy at a given time point after commencing therapy.

A patient experiencing a smaller decline or a patient whose tau protein deposits remains constant or even increases, but to a lesser extent than expected in the absence of immunotherapy (*e.g.*, as inferred from a control group of patients not administered immunotherapy) can be classified as experiencing a positive but suboptimal response. Such patients can optionally be subject to an adjustment of regime in which the dose and or frequency of administration of an agent is increased.

[0316] In some patients, tau protein deposits may increase in similar or greater fashion to tau deposits in patients not receiving immunotherapy. If such increases persist over a period of time, such as 18 months or 2 years, even after any increase in the frequency or dose of agents, immunotherapy can if desired be discontinued in favor of other treatments.

[0317] The foregoing description of diagnosing, monitoring, and adjusting treatment for tauopathies has been largely focused on using PET scans. However, any other technique for visualizing and/or measuring tau protein deposits that is amenable to the use of tau antibodies of the invention (*e.g.*, a mouse, humanized, chimeric or veneered 3D6 antibody) can be used in place of PET scans to perform such methods.

[0318] Also provided are methods of detecting an immune response against tau in a patient suffering from or susceptible to diseases associated with tau. The methods can be used to monitor a course of therapeutic and prophylactic treatment with the agents provided herein. The antibody profile following passive immunization typically shows an immediate peak in antibody concentration followed by an exponential decay. Without a further dose, the decay approaches pretreatment levels within a period of days to months depending on the half-life of the antibody administered. For example, the half-life of some human antibodies is of the order of 20 days.

[0319] In some methods, a baseline measurement of antibody to tau in the subject is made before administration, a second measurement is made soon thereafter to determine the peak antibody level, and one or more further measurements are made at intervals to monitor decay of antibody levels. When the level of antibody has declined to baseline or a predetermined percentage of the peak less baseline (*e.g.*, 50%, 25% or 10%), administration of a further dose of antibody is administered. In some methods, peak or subsequent measured levels less background are compared with reference levels previously determined to constitute a beneficial prophylactic

or therapeutic treatment regime in other subjects. If the measured antibody level is significantly less than a reference level (*e.g.*, less than the mean minus one or, preferably, two standard deviations of the reference value in a population of subjects benefiting from treatment) administration of an additional dose of antibody is indicated.

[0320] Also provided are methods of detecting tau in a subject, for example, by measuring tau in a sample from a subject or by *in vivo* imaging of tau in a subject. Such methods are useful to diagnose or confirm diagnosis of diseases associated with tau, or susceptibility thereto. The methods can also be used on asymptomatic subjects. The presence of tau indicates susceptibility to future symptomatic disease. The methods are also useful for monitoring disease progression and/or response to treatment in subjects who have been previously diagnosed with Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

[0321] Biological samples obtained from a subject having, suspected of having, or at risk of having Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP) can be contacted with the antibodies disclosed herein to assess the presence of tau. For example, levels of tau in such subjects may be compared to those present in healthy subjects. Alternatively, levels of tau in such subjects receiving treatment for the disease may be compared to those of subjects who have not been treated for Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy,

postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP). Some such tests involve a biopsy of tissue obtained from such subjects. ELISA assays may also be useful methods, for example, for assessing tau in fluid samples.

VII. Kits

[0322] The invention further provides kits (*e.g.*, containers) comprising an antibody disclosed herein and related materials, such as instructions for use (*e.g.*, package insert). The instructions for use may contain, for example, instructions for administration of the antibody and optionally one or more additional agents. The containers of antibody may be unit doses, bulk packages *(e.g.*, multi-dose packages), or sub-unit doses.

[0323] Package insert refers to instructions customarily included in commercial packages of therapeutic products that contain information about the indications, usage, dosage, administration, contraindications and/or warnings concerning the use of such therapeutic products

[0324] Kits can also include a second container comprising a pharmaceutically-acceptable buffer, such as bacteriostatic water for injection (BWFI), phosphate-buffered saline, Ringer's solution and dextrose solution. It can also include other materials desirable from a commercial and user standpoint, including other buffers, diluents, filters, needles, and syringes.

VIII. Other Applications

[0325] The antibodies can be used for detecting tau, or fragments thereof, in the context of clinical diagnosis or treatment or in research. For example, the antibodies can be used to detect the presence of tau in a biological sample as an indication that the biological sample comprises tau deposits. Binding of the antibodies to the biological sample can be compared to binding of the antibodies to a control sample. The control sample and the biological sample can comprise cells of the same tissue origin. Control samples and biological samples can be obtained from the

same individual or different individuals and on the same occasion or on different occasions. If desired, multiple biological samples and multiple control samples are evaluated on multiple occasions to protect against random variation independent of the differences between the samples. A direct comparison can then be made between the biological sample(s) and the control sample(s) to determine whether antibody binding (*i.e.*, the presence of tau) to the biological sample(s) is increased, decreased, or the same relative to antibody binding to the control sample(s). Increased binding of the antibody to the biological sample(s) relative to the control sample(s) indicates the presence of tau in the biological sample(s). In some instances, the increased antibody binding is statistically significant. Optionally, antibody binding to the biological sample is at least 1.5-fold, 2-fold, 3-fold, 4-fold, 5-fold, 10-fold, 20-fold, or 100-fold higher than antibody binding to the control sample.

[0326] In addition, the antibodies can be used to detect the presence of the tau in a biological sample to monitor and evaluate the efficacy of a therapeutic agent being used to treat a patient diagnosed with Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP). A biological sample from a patient diagnosed with Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP) is evaluated to establish a baseline for the binding of the antibodies to the sample (*i.e.*, a baseline for the presence of the tau in the sample) before

commencing therapy with the therapeutic agent. In some instances, multiple biological samples from the patient are evaluated on multiple occasions to establish both a baseline and measure of random variation independent of treatment. A therapeutic agent is then administered in a regime. The regime may include multiple administrations of the agent over a period of time. Optionally, binding of the antibodies (*i.e.*, presence of tau) is evaluated on multiple occasions in multiple biological samples from the patient, both to establish a measure of random variation and to show a trend in response to immunotherapy. The various assessments of antibody binding to the biological samples are then compared. If only two assessments are made, a direct comparison can be made between the two assessments to determine whether antibody binding (*i.e.*, presence of tau) has increased, decreased, or remained the same between the two assessments. If more than two measurements are made, the measurements can be analyzed as a time course starting before treatment with the therapeutic agent and proceeding through the course of therapy. In patients for whom antibody binding to biological samples has decreased (*i.e.*, the presence of tau), it can be concluded that the therapeutic agent was effective in treating the Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP) in the patient. The decrease in antibody binding can be statistically significant. Optionally, binding decreases by at least 1%, 2%, 3%, 4%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100%. Assessment of antibody binding can be made in conjunction with assessing other signs and symptoms of Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer

disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

[0327] The antibodies can also be used as research reagents for laboratory research in detecting tau, or fragments thereof. In such uses, antibodies can be labeled with fluorescent molecules, spin-labeled molecules, enzymes, or radioisotopes, and can be provided in the form of kit with all the necessary reagents to perform the detection assay. The antibodies can also be used to purify tau, or binding partners of tau, *e.g.*, by affinity chromatography.

[0328] All patent filings, websites, other publications, accession numbers and the like cited above or below are incorporated by reference in their entirety for all purposes to the same extent as if each individual item were specifically and individually indicated to be so incorporated by reference. If different versions of a sequence are associated with an accession number at different times, the version associated with the accession number at the effective filing date of this application is meant. The effective filing date means the earlier of the actual filing date or filing date of a priority application referring to the accession number if applicable. Likewise if different versions of a publication, website or the like are published at different times, the version most recently published at the effective filing date of the application is meant unless otherwise indicated. Any feature, step, element, embodiment, or aspect of the invention can be used in combination with any other unless specifically indicated otherwise. Although the present invention 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.

EXAMPLES

Example 1. Identification of tau Monoclonal Antibodies

[0329] Monoclonal antibodies against tau were generated as follows. Immunizations were performed with either recombinant N-terminally His-tagged 383 a.a. human tau (4R0N), containing a P301S mutation [immunogen A] or recombinant 383 a.a. human tau (4R0N), containing a P301S mutation, lacking an N-terminal His-tag [immunogen B]. Immunogens were emulsified in RIBI adjuvant.

[0330] Five week old female Balb/c mice were intraperitoneally immunized with 25μg of immunogen A on day 0, and 10μg of immunogen A each on days 7, 14, 21, 27, 34, 48, 55, and 62. Mice were immunized with 10μg of immunogen B on days 76 and 90. On days 43 and 98, mice were bled and titered against immunogen A; on day 101 the animals with highest titers were boosted with a terminal immunization of 50μg immunogen B, which was delivered ½ intraperitoneally and ½ intravenously. Fused hybridomas were screened via ELISA against both immunogens, and positives with the highest signal were epitope mapped (see Example 2)..

Example 2. Epitope mapping of antibody 3D6

[0331] A range of overlapping biotinylated peptides spanning the entire 383aa 4R0N human tau protein were used for mapping the murine 3D6 antibody. Additional peptides were used to model potential post-translational modifications of the C- and N-terminal ends of the protein.

[0332] Biotinylated peptides were bound to separate wells of a streptavidin-coated ELISA plate. The plate was blocked and treated with murine 3D6, followed by incubation with a horseradish peroxidase-conjugated anti-mouse antibody. After thorough washing, OPD was applied to the plate and allowed to develop. The plate was read at 450nm absorbance. Background subtraction was performed with absorbance values from wells containing no primary antibody, and a threshold for positive binding was set to 0.2 absorbance units. Binding was mapped to sites within the MTBR region.

Example 3. Design of Humanized 3D6 Antibodies

[0333] The starting point or donor antibody for humanization was the mouse antibody 3D6. The heavy chain variable amino acid sequence of mature m3D6 is provided as SEQ ID NO:7. The light chain variable amino acid sequence of mature m3D6 is provided as SEQ ID NO:11. The heavy chain Kabat/Chothia Composite CDR1, CDR2, and CDR3 amino acid sequences are provided as SEQ ID NOs:8-10, respectively. The light chain Kabat CDR1, CDR2, and CDR3 amino acid sequences are provided as SEQ ID NOs12-14 respectively. Kabat numbering is used throughout.

[0334] The variable kappa (Vk) of 3D6 belongs to mouse Kabat subgroup 2 which corresponds to human Kabat subgroup 2 and the variable heavy (Vh) to mouse Kabat subgroup 2c which corresponds to human Kabat subgroup 1 [Kabat E.A., et al., (1991), Sequences of Proteins of

Immunological Interest, Fifth Edition. NIH Publication No. 91-3242]. 16 residue Chothia CDR-L1 belongs to canonical class 4, 7 residue Chothia CDR-L2 to class 1, 9 residue Chothia CDR-L3 to class 1 in Vk [Martin A.C, and Thornton J.M. (1996) J. Mol. Biol. 263:800-15. [Martin & Thornton, 1996]. 10 residue Chothia CDR-H1 belongs to class 1, 17 residue Chothia CDR-H2 to class 2 [Martin & Thornton, 1996]]. CDR-H3 has no canonical classes. A search was made over the protein sequences in the PDB database [Deshpande N, et al., (2005) Nucleic Acids Res. 33: D233-7.] to find structures which would provide a rough structural model of 3D6. To build up a Fv model of 3D6, a .structure of murine anti-pyroglutamate-Abeta antibody Fab c#24 (pdb code 5MYX) [Piechotta, A. et al., 2017, J Biol Chem. 292: 12713–12724] with a resolution of 1.4 A was used. It retained the same canonical structure for the loops as 3D6.

[0335] The frameworks of 3D6 VH share a high degree of sequence similarity with the corresponding regions of humanized 48G7 Fab PDB: 2RCS, designed by Wedemayer, G. J., et al. (1997; Science 276: 1665-1669). The variable domains of 3D6 and 48G7 fab also share identical lengths for the CDR-H1, H2 loops. Similarly, the frameworks of 3D6 VL share a high degree of sequence similarity with the corresponding regions of human antibody ARX71335 VL, cloned by Dafferner, A. J., et al. (2017; . Direct Submission). The variable light domain of 3D6 and ARX71335 antibody also share identical lengths for the CDR-L1, L2 and L3 loops. Accordingly, the framework regions of 48G7 VH (2RCS-VH) and ARX71335 VL were chosen as the acceptor sequences for the CDRs of 3D6. A model of the 3D6 CDRs grafted onto the respective human frame-works for VH and VL was built and used as a guidance for further backmutations.

[0336] Heavy and light chain variant sequences resulting from antibody humanization process were further aligned to human germ line sequences using IMGT Domain GapAlign tool to assess the humanness of the heavy and light chain as outlined by WHO INN committee guidelines. (WHO-INN: International nonproprietary names (INN) for biological and biotechnological substances (a review) (Internet) 2014. Available from: http://www. who.int/medicines/services/inn/BioRev2014.pdf) Residues were changed to align with corresponding human germ line sequence, where possible, to enhance humanness and to reduce potential immunogenicity. For humanized VLvb2 and VLvb3 variants, mutations were introduced to render the sequences more similar to human germ line gene IGKV2-30*02 (SEQ

ID NO:27) For humanized VHvb2, VHvb3, VHvb4, VHvb5, VHvb6, and VHvb6 variants, mutations were introduced to render the sequences more similar to human germ line gene IGHV1-69-2*01 (SEQ ID NO:25)

[0337] Versions of hu3D6-VH and hu3D6-VL were designed to enable assessment of various framework residues for their contributions to antigen binding, thermostability, and immunogenicity, and for optimization of glycosylation, aggregation, N-term heterogeneity, thermostability, surface exposed charged patches, surface exposed charge patches, deamination, and proteinase susceptibility. The positions considered for mutation include those that…

- define the canonical CDR conformations (summarized in Martin, A.C.R. (2010) Protein sequence and structure analysis of antibody variable domains. In: Kontermann R and Dübel S (eds). *Antibody Engineering*. Heidelberg, Germany: Springer International Publishing AG.),

- are within the Vernier zone (Foote J and Winter G. (1992) Antibody framework residues affecting the conformation of the hypervariable loops. *J Mol Biol*. 224(2):487-99.),

- localize to the VH/VL domain interface (summarized in Léger OJP and Saldanha J. (2000) Preparation of recombinant antibodies from immune rodent spleens and the design of their humanisation by CDR grafting. In: Shepherd P and Dean C (eds). *Monoclonal Antibodies: a Practical Approach*. Oxford, UK: Oxford University Press.),

- are susceptible to post-translational modifications, such as glycosylation or pyroglutamination,

- are occupied by residues that are predicted to clash with CDRs, according to the model of 3D6 CDRs grafted onto VH and VL frameworks, or

- are occupied by residues that are rare among sequenced human antibodies, where either the parental mouse 3D6 residue or some other residue is much more prevalent within human antibody repertoire.

[0338] Alignments of the murine 3D6 and various humanized antibodies are shown for the light chain variable regions (Table 4 and Figure 2), and heavy chain variable regions (Table 3 and Figure 1).

[0339] 7 humanized heavy chain variable region variants and 3 humanized light chain variable region variants were constructed containing different permutations of substitutions: hu3D6VHvb1, hu3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6Hvb5, hu3D6VHvb6, or hu3D6VHvb7 (SEQ ID NOs:76-80 and 90-91, respectively); and hu3D6VLvb1, hu3D6VLvb2, or hu3D6VLvb3 (SEQ ID NOs:83-85, respectively) (Tables 3 and 4). The exemplary humanized Vk and Vh designs, with backmutations and other mutations based on selected human frameworks, are shown in Tables 3 and 4, respectively. The bolded areas in Tables 3 and 4 indicate the CDRs as defined by Kabat/Chothia Composite. SEQ ID NOs:76-80 and SEQ ID NOs:90-91 contain backmutations and other mutations as shown in Table 5. The amino acids at positions in hu3D6VHvb1, hu3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6VHvb5, hu3D6VHvb6, and hu3D6VHvb7 are listed in Table 6. The amino acids at positions in hu3D6VLvb1, hu3D6VLvb2, and hu3D6VLvb3 are listed in Table 7. The percentage humanness for humanized VH chains hu3D6VHvb1, hu3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6Hvb5, hu3D6VHvb6, and hu3D6VHvb7 (SEQ ID NOs:76-80 and 90-91, respectively) and humanized VL chains hu3D6VLvb1, hu3D6VLvb2, and hu3D6VLvb3 (SEQ ID NOs:83-85, respectively) is shown in Table 8.

Table 3

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
1	1	Fr1	E	E	Q	Q	E	E	E	E	E	E
2	2	Fr1	V	V	V	V	V	V	V	V	V	V
3	3	Fr1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
4	4	Fr1	L	L	L	L	L	L	L	L	L	L
5	5	Fr1	Q	V	Q	Q	V	V	V	V	V	V
6	6	Fr1	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
7	7	Fr1	S	S	S	S	S	S	S	S	S	S
8	8	Fr1	G	G	G	G	G	G	G	G	G	G
9	9	Fr1	A	A	A	A	A	A	A	A	A	A
10	10	Fr1	D	E	E	E	E	E	E	E	E	E
11	11	Fr1	L	V	L	L	V	V	V	V	V	V
12	12	Fr1	V	K	V	V	V	V	V	V	V	V
13	13	Fr1	R	K	K	K	K	K	K	K	K	K
14	14	Fr1	P	P	P	P	P	P	P	P	P	P
15	15	Fr1	G	G	G	G	G	G	G	G	G	G
16	16	Fr1	A	A	A	A	A	A	A	A	A	A
17	17	Fr1	L	T	S	S	S	T	T	T	T	T
18	18	Fr1	V	V	V	V	V	V	V	V	V	V
19	19	Fr1	K	K	K	K	K	K	K	K	K	K
20	20	Fr1	L	I	L	L	I	I	I	I	I	I

Kabat residue #	21	22	23	24	25	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**35A**	**35B**	36	37	38	39
Linear residue #	21	22	23	24	25	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**			36	37	38	39
FR or CDR	Fr1	Fr1	Fr1	Fr1	Fr1	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	**CDR-H1**	Fr2	Fr2	Fr2	Fr2
Mouse 3D6 VH (SEQ ID NO:7)	S	C	K	A	S	**G**	**F**	**N**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	S	C	K	V	S	**G**	**Y**	**T**	**F**	**T**	**D**	**Y**	**Y**	**M**	**H**			W	V	Q	Q
2RCS-VH_huFrwk (SEQ ID NO:75)	S	C	T	A	S	**G**	**F**	**N**	**I**	**K**	**D**	**T**	**Y**	**M**	**H**	-	-	W	V	K	Q
Hu3D6 VHvb1 (SEQ ID NO:76)	S	C	T	A	S	**G**	**F**	**N**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	K	Q
Hu3D6 VHvb2 (SEQ ID NO:77)	S	C	K	A	S	**G**	**F**	**N**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
Hu3D6 VHvb3 (SEQ ID NO:78)	S	C	K	A	S	**G**	**F**	**N**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
Hu3D6 VHvvb4 (SEQ ID NO:79)	S	C	K	A	S	**G**	**F**	**T**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
Hu3D6 VHvb5 (SEQ ID NO:80)	S	C	K	A	S	**G**	**F**	**T**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
Hu3D6 VHvb6 (SEQ ID NO:90)	S	C	K	A	S	**G**	**F**	**T**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q
Hu3D6 VHvb7 (SEQ ID NO:91)	S	C	K	A	S	**G**	**F**	**T**	**I**	**K**	**D**	**Y**	**Y**	**L**	**H**	-	-	W	V	R	Q

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
40	40	Fr2	R	A	R	R	R	R	R	R	R	R
41	41	Fr2	P	P	P	P	P	P	P	P	P	P
42	42	Fr2	E	G	E	E	G	G	G	G	G	G
43	43	Fr2	Q	K	Q	Q	K	K	K	K	K	K
44	44	Fr2	G	G	G	G	G	G	G	G	G	G
45	45	Fr2	L	L	L	L	L	L	L	L	L	L
46	46	Fr2	E	E	E	E	E	E	E	E	E	E
47	47	Fr2	W	W	W	W	W	W	W	W	W	W
48	48	Fr2	I	M	I	I	I	I	I	I	I	I
49	49	Fr2	G	G	G	G	G	G	G	G	G	G
50	**50**	**CDR-H2**	**W**	**L**	**R**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
51	**51**	**CDR-H2**	**I**	**V**	**I**	**I**	**I**	**I**	**I**	**I**	**I**	**I**
52	**52**	**CDR-H2**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**
52A	**53**	**CDR-H2**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
52B		**CDR-H2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
52C		**CDR-H2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
53	**54**	**CDR-H2**	**E**	**E**	**A**	**E**	**E**	**E**	**E**	**E**	**E**	**E**
54	**55**	**CDR-H2**	**N**	**D**	**N**	**N**	**N**	**N**	**N**	**D**	**D**	**D**
55	**56**	**CDR-H2**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**
56	**57**	**CDR-H2**	**D**	**E**	**N**	**D**	**D**	**D**	**D**	**E**	**E**	**E**
57	**58**	**CDR-H2**	**T**	**T**	**T**	**T**	**T**	**T**	**T**	**T**	**T**	**T**

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
58	**59**	**CDR-H2**	**V**	**I**	**K**	**V**	**V**	**I**	**I**	**I**	**V**	**V**
59	**60**	**CDR-H2**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
60	**61**	**CDR-H2**	**D**	**A**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**
61	**62**	**CDR-H2**	**P**	**E**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
62	**63**	**CDR-H2**	**K**	**K**	**K**	**K**	**K**	**K**	**K**	**K**	**K**	**K**
63	**64**	**CDR-H2**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**
64	**65**	**CDR-H2**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**
65	**66**	**CDR-H2**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**	**G**
66	67	Fr3	K	R	K	K	R	R	R	R	R	R
67	68	Fr3	A	V	A	A	A	A	V	V	V	V
68	69	Fr3	T	T	T	T	T	T	T	T	T	T
69	70	Fr3	I	I	I	I	I	I	I	I	I	I
70	71	Fr3	T	T	T	T	T	T	T	T	T	T
71	72	Fr3	A	A	A	A	A	A	A	A	A	A
72	73	Fr3	D	D	D	D	D	D	D	D	D	D
73	74	Fr3	T	T	T	T	T	T	T	T	T	T
74	75	Fr3	S	S	S	S	S	S	S	S	S	S
75	76	Fr3	S	T	S	S	T	T	T	T	T	T
76	77	Fr3	N	D	N	N	D	D	D	D	D	D
77	78	Fr3	T	T	T	T	T	T	T	T	T	T
78	79	Fr3	A	A	A	A	A	A	A	A	A	A

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
79	80	Fr3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
80	81	Fr3	L	M	L	L	L	M	M	M	M	M
81	82	Fr3	Q	E	Q	Q	E	E	E	E	E	E
82	83	Fr3	L	L	L	L	L	L	L	L	L	L
82A	84	Fr3	G	S	S	S	S	S	S	S	S	S
82B	85	Fr3	S	S	S	S	S	S	S	S	S	S
82C	86	Fr3	L	L	L	L	L	L	L	L	L	L
83	87	Fr3	T	R	T	T	T	R	R	R	R	R
84	88	Fr3	S	S	S	S	S	S	S	S	S	S
85	89	Fr3	E	E	E	E	E	E	E	E	E	E
86	90	Fr3	D	D	D	D	D	D	D	D	D	D
87	91	Fr3	T	T	T	T	T	T	T	T	T	T
88	92	Fr3	A	A	A	A	A	A	A	A	A	A
89	93	Fr3	V	V	V	V	V	V	V	V	V	V
90	94	Fr3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
91	95	Fr3	F	Y	Y	F	F	Y	Y	Y	F	Y
92	96	Fr3	C	C	C	C	C	C	C	C	C	C
93	97	Fr3	S	A	A	S	S	S	S	S	S	S
94	98	Fr3	T	T	S	T	T	T	T	T	T	T
95	**99**	**CDR-H3**	**L**		**Y**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
96		**CDR-H3**	-		**Y**	-	-	-	-	-	-	-

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
97		**CDR-H3**	-		**G**	-	G	G	G	G	G	G
98		**CDR-H3**	-		-	-	Q	Q	Q	Q	Q	Q
99		**CDR-H3**	-		-	-	G	G	G	G	G	G
100		**CDR-H3**	-		-	-	W	W	W	W	W	W
100A		**CDR-H3**	-		-	-	F	F	F	F	F	F
100B		**CDR-H3**	-		-	-	D	D	D	D	D	D
100C		**CDR-H3**	-		-	-	-	-	-	-	-	-
100D		**CDR-H3**	-		-	-	-	-	-	-	-	-
100E		**CDR-H3**	-		-	-	-	-	-	-	-	-
100F		**CDR-H3**	-		-	-	-	-	-	-	-	-
100G		**CDR-H3**	-		-	-	-	-	-	-	-	-
100H		**CDR-H3**	-			-	-	-	-	-	-	-
100I		**CDR-H3**	-			-	-	-	-	-	-	-
100J		**CDR-H3**	-			-	-	-	-	-	-	-
100K		**CDR-H3**	-			-	-	-	-	-	-	-
101	**100**	**CDR-H3**	**D**	**Q**	**I**	**D**	-	-	-	-	-	-
102	**101**	**CDR-H3**	**F**	**H**	**Y**	**F**	-	-	-	-	-	-
103	102	Fr4	W	W	W	W	G	G	G	G	G	G
104	103	Fr4	G	G	G	G	Q	Q	Q	Q	Q	Q
105	104	Fr4	Q	Q	Q	Q	G	G	G	G	G	G
106	105	Fr4	G	G	G	G	T	T	T	T	T	T

Kabat residue #	Linear residue #	FR or CDR	Mouse 3D6 VH (SEQ ID NO:7)	IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	2RCS-VH_huFrwk (SEQ ID NO:75)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
107	106	Fr4	T	T	T	T	T	T	T	T	T	T
108	107	Fr4	T	L	T	T	L	L	L	L	L	L
109	108	Fr4	L	V	L	L	V	V	V	V	V	V
110	109	Fr4	T	T	T	T	T	T	T	T	T	T
111	110	Fr4	V	V	V	V	V	V	V	V	V	V
112	111	Fr4	S	S	S	S	S	S	S	S	S	S
113	112	Fr4	S	S	S	S	S	S	S	S	S	S

Table 4

Kabat residue #	Linear residue #	FR or CDR	Mouse VL 3D6 (SEQ ID NO:11)	ARX71335-VL_huFrwk (SEQ ID NO:82)	IMGT#IGKV2-30*02 (SEQ ID NO:27)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
1	1	Fr1	D	D	D	D	D	D
2	2	Fr1	V	V	V	V	V	V
3	3	Fr1	V	V	V	V	V	V
4	4	Fr1	M	M	M	M	M	M
5	5	Fr1	T	T	T	T	T	T
6	6	Fr1	Q	Q	Q	Q	Q	Q
7	7	Fr1	T	T	S	T	S	S
8	8	Fr1	P	P	P	P	P	P
9	9	Fr1	L	L	L	L	L	L
10	10	Fr1	T	T	S	T	S	S
11	11	Fr1	L	L	L	L	L	L
12	12	Fr1	S	S	P	S	S	S
13	13	Fr1	V	V	V	V	V	V
14	14	Fr1	T	T	T	T	T	T
15	15	Fr1	I	I	L	I	L	L
16	16	Fr1	G	G	G	G	G	G
17	17	Fr1	Q	Q	Q	Q	Q	E
18	18	Fr1	P	P	P	P	P	P
19	19	Fr1	A	A	A	A	A	A
20	20	Fr1	S	S	S	S	S	S
21	21	Fr1	I	I	I	I	I	I
22	22	Fr1	S	S	S	S	S	S
23	23	Fr1	C	C	C	C	C	C

Kabat residue #	Linear residue #	FR or CDR	Mouse VL 3D6 (SEQ ID NO:11)	ARX71335-VL_huFrwk (SEQ ID NO:82)	IMGT#IGKV2-30*02 (SEQ ID NO:27)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
24	24	CDR-L1	K	K	R	K	K	R
25	25	CDR-L1	S	S	S	S	S	S
26	26	CDR-L1	S	S	S	S	S	S
27	27	CDR-L1	Q	Q	Q	Q	Q	Q
27A	28	CDR-L1	S	S	S	S	S	S
27B	29	CDR-L1	L	L	L	L	L	L
27C	30	CDR-L1	L	L	V	L	L	L
27D	31	CDR-L1	D	Y	H	D	D	D
27E	32	CDR-L1	S	S	S	S	S	S
27F		CDR-L1	-					
28	33	CDR-L1	D	N	D	D	D	D
29	34	CDR-L1	G	G	G	G	G	G
30	35	CDR-L1	K	K	N	K	K	K
31	36	CDR-L1	T	T	T	T	T	T
32	37	CDR-L1	Y	Y	Y	Y	Y	Y
33	38	CDR-L1	L	L	L	L	L	L
34	39	CDR-L1	N	N	N	N	N	N
35	40	Fr2	W	W	W	W	W	W
36	41	Fr2	L	L	F	L	L	L
37	42	Fr2	L	L	Q	L	L	Q
38	43	Fr2	Q	Q	Q	Q	Q	Q
39	44	Fr2	R	R	R	R	R	R
40	45	Fr2	P	P	P	P	P	P
41	46	Fr2	G	G	G	G	G	G

Kabat residue #	Linear residue #	FR or CDR	Mouse VL 3D6 (SEQ ID NO:11)	ARX71335-VL_huFrwk (SEQ ID NO:82)	IMGT#IGKV2-30*02 (SEQ ID NO:27)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
42	47	Fr2	Q	Q	Q	Q	Q	Q
43	48	Fr2	S	S	S	S	S	S
44	49	Fr2	P	P	P	P	P	P
45	50	Fr2	K	K	R	K	K	R
46	51	Fr2	R	R	R	R	R	R
47	52	Fr2	L	L	L	L	L	L
48	53	Fr2	I	I	I	I	I	I
49	54	Fr2	Y	Y	Y	Y	Y	Y
50	**55**	**CDR-L2**	**L**	**L**	**K**	**L**	**L**	**L**
51	**56**	**CDR-L2**	**V**	**V**	**V**	**V**	**V**	**V**
52	**57**	**CDR-L2**	**S**	**S**	**S**	**S**	**S**	**S**
53	**58**	**CDR-L2**	**K**	**K**	**N**	**K**	**K**	**K**
54	**59**	**CDR-L2**	**L**	**L**	**R**	**L**	**L**	**L**
55	**60**	**CDR-L2**	**D**	**D**	**D**	**D**	**D**	**D**
56	**61**	**CDR-L2**	**S**	**S**	**S**	**S**	**S**	**S**
57	62	Fr3	G	G	G	G	G	G
58	63	Fr3	V	V	V	V	V	V
59	64	Fr3	P	P	P	P	P	P
60	65	Fr3	D	D	D	D	D	D
61	66	Fr3	R	R	R	R	R	R
62	67	Fr3	F	F	F	F	F	F
63	68	Fr3	T	S	S	S	S	S
64	69	Fr3	G	G	G	G	G	G
65	70	Fr3	S	S	S	S	S	S

Kabat residue #	Linear residue #	FR or CDR	Mouse VL 3D6 (SEQ ID NO:11)	ARX71335-VL_huFrwk (SEQ ID NO:82)	IMGT#IGKV2-30*02 (SEQ ID NO:27)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
66	71	Fr3	G	G	G	G	G	G
67	72	Fr3	S	S	S	S	S	S
68	73	Fr3	G	G	G	G	G	G
69	74	Fr3	T	T	T	T	T	T
70	75	Fr3	D	D	D	D	D	D
71	76	Fr3	F	F	F	F	F	F
72	77	Fr3	T	T	T	T	T	T
73	78	Fr3	L	L	L	L	L	L
74	79	Fr3	K	K	K	K	K	K
75	80	Fr3	I	I	I	I	I	I
76	81	Fr3	S	S	S	S	S	S
77	82	Fr3	R	R	R	R	R	R
78	83	Fr3	V	V	V	V	V	V
79	84	Fr3	E	E	E	E	E	E
80	85	Fr3	A	A	A	A	A	A
81	86	Fr3	E	E	E	E	E	E
82	87	Fr3	D	D	D	D	D	D
83	88	Fr3	L	L	V	L	V	V
84	89	Fr3	G	G	G	G	G	G
85	90	Fr3	V	V	V	V	V	V
86	91	Fr3	Y	H	Y	H	Y	Y
87	92	Fr3	Y	Y	Y	Y	Y	Y
88	93	Fr3	C	C	C	C	C	C
89	**94**	**CDR-L3**	**W**	**E**	**M**	**W**	**W**	**W**

Kabat residue #	Linear residue #	FR or CDR	Mouse VL 3D6 (SEQ ID NO:11)	ARX71335-VL_huFrwk (SEQ ID NO:82)	IMGT#IGKV2-30*02 (SEQ ID NO:27)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
90	**95**	**CDR-L3**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**
91	**96**	**CDR-L3**	**G**	**G**	**G**	**G**	**G**	**G**
92	**97**	**CDR-L3**	**T**	**T**	**T**	**T**	**T**	**T**
93	**98**	**CDR-L3**	**H**	**H**	**H**	**H**	**H**	**H**
94	**99**	**CDR-L3**	**F**	**F**	**W**	**F**	**F**	**F**
95	**100**	**CDR-L3**	**P**	**P**	**P**	**P**	**P**	**P**
95A		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
95B		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
95C		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
95D		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
95E		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
95F		**CDR-L3**	**-**	**-**	**-**	**-**	**-**	**-**
96	**101**	**CDR-L3**	**Y**	**L**	**Y**	**Y**	**Y**	**Y**
97	**102**	**CDR-L3**	**T**	**T**	**T**	**T**	**T**	**T**
98	103	Fr4	F	F	F	F	F	F
99	104	Fr4	G	G	G	G	G	G
100	105	Fr4	G	A	Q	A	A	Q
101	106	Fr4	G	G	G	G	G	G
102	107	Fr4	T	T	T	T	T	T
103	108	Fr4	K	K	K	K	K	K
104	109	Fr4	L	L	L	L	L	L
105	110	Fr4	E	E	E	E	E	E
106	111	Fr4	I	L	I	L	I	I
106A	112	Fr4	K	K	K	K	K	K

107	Kabat residue #
113	Linear residue #
Fr4	FR or CDR
R	Mouse VL 3D6 (SEQ ID NO:11)
	ARX71335-VL_huFrwk (SEQ ID NO:82)
	IMGT#IGKV2-30*02 (SEQ ID NO:27)
R	Hu3D6VLvb1 (SEQ ID NO:83)
R	Hu3D6VLvb2 (SEQ ID NO:84)
R	Hu3D6VLvb3 (SEQ ID NO:85)

[0340] Table 5: V_H, V_L Backmutations and Other Mutations for Humanized 3D6

V_H or V_L Variant	V_H or V_L Exon Acceptor Sequence	Changes from Acceptor Framework (or CDR) Residues (based on Kabat/Chothia Composite CDRs)
Hu3D6VHvb1 (SEQ ID NO:76)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H91, H93, H94
Hu3D6VHvb2 (SEQ ID NO:77)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H20, H23, H38, H42, H43, H66, H67, H75, H76, H81, H91, H93, H94
Hu3D6VHvb3 (SEQ ID NO:78)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H17, H20, H23, H38, H42, H43, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, H109
Hu3D6VHvb4 (SEQ ID NO:79)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, H109
Hu3D6VHvb5 (SEQ ID NO:80)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, H109
Hu3D6 VHvb6 (SEQ ID NO:90)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H91, H93, H94, H108, H109
Hu3D6 VHvb7 (SEQ ID NO:91)	PDB ID 2RCS-VH_huFrwk (SEQ ID NO:75) IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, H109
Hu3D6VLvb1 (SEQ ID NO:83)	PDB ID ARX71335-VL_huFrwk (SEQ ID NO:82); IMGT#IGKV2-30*02 (SEQ ID NO:27)	
Hu3D6VLvb2 (SEQ ID NO:84)	PDB ID ARX71335-VL_huFrwk (SEQ ID NO:82); IMGT#IGKV2-30*02 (SEQ ID NO:27)	L7, L10, L15, L83, L86, L106
Hu3D6VLvb3 (SEQ ID NO:85)	PDB ID ARX71335-VL_huFrwk (SEQ ID NO:82); IMGT#IGKV2-30*02 (SEQ ID NO:27)	L7, L10, L15, L17, L24, L37, L45, L83, L86, L100, L106

[0341] Table 6: Kabat Numbering of Framework (or CDR) Residues (based on Kabat/Chothia Composite CDRs) for Backmutations and Other Mutations in Heavy Chains of Humanized 3D6 Antibodies

Residue	2RCS-VH_huFrwk (SEQ ID NO:75)	(Heavy Chain)IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	Mouse 3D6 (SEQ ID NO:7)	Hu3D6 VHvb1 (SEQ ID NO:76)	Hu3D6 VHvb2 (SEQ ID NO:77)	Hu3D6 VHvb3 (SEQ ID NO:78)	Hu3D6 VHvvb4 (SEQ ID NO:79)	Hu3D6 VHvb5 (SEQ ID NO:80)	Hu3D6 VHvb6 (SEQ ID NO:90)	Hu3D6 VHvb7 (SEQ ID NO:91)
H1	Q	E	E	Q	E	E	E	E	E	E
H5	Q	V	Q	Q	V	V	V	V	V	V
H11	L	V	L	L	V	V	V	V	V	V
H17	S	T	L	S	S	T	T	T	T	T
H20	L	I	L	L	I	I	I	I	I	I
H23	T	K	K	T	K	K	K	K	K	K
H28	N	T	N	N	N	N	T	T	T	T
H38	K	Q	R	K	R	R	R	R	R	R
H42	E	G	E	E	G	G	G	G	G	G
H43	Q	K	Q	Q	K	K	K	K	K	K
H54	N	D	N	N	N	N	N	D	D	D
H56	N	E	D	D	D	D	D	E	E	E
H58	K	I	V	V	V	I	I	I	V	V
H66	K	R	K	K	R	R	R	R	R	R
H67	A	V	A	A	A	A	V	V	V	V

Residue	H75	H76	H80	H81	H83	H91	H93	H94	H108	H109
2RCS-VH_huFrwk (SEQ ID NO:75)	S	N	L	Q	T	Y	A	S	T	L
(Heavy Chain)IMGT# IGHV1-69-2*01 (SEQ ID NO:25)	T	D	M	E	R	Y	A	T	L	V
Mouse 3D6 (SEQ ID NO:7)	S	N	L	Q	T	F	S	T	T	L
Hu3D6 VHvb1 (SEQ ID NO:76)	S	N	L	Q	T	F	S	T	T	L
Hu3D6 VHvb2 (SEQ ID NO:77)	T	D	L	E	T	F	S	T	L	V
Hu3D6 VHvb3 (SEQ ID NO:78)	T	D	M	E	R	Y	S	T	L	V
Hu3D6 VHvvb4 (SEQ ID NO:79)	T	D	M	E	R	Y	S	T	L	V
Hu3D6 VHvb5 (SEQ ID NO:80)	T	D	M	E	R	Y	S	T	L	V
Hu3D6 VHvb6 (SEQ ID NO:90)	T	D	M	E	R	F	S	T	L	V
Hu3D6 VHvb7 (SEQ ID NO:91)	T	D	M	E	R	Y	S	T	L	V

[0342] Table 7: Kabat Numbering of Framework Residues (based on Kabat/Chothia Composite CDRs) for Backmutations and Other Mutations in Light Chains of Humanized 3D6 Antibodies

Residue	ARX71335-VL huFrwk (SEQ ID NO:82)	(Light Chain) IMGT#IGKV2-30*02 (SEQ ID NO:27)	Mouse 3D6 (SEQ ID NO:11)	Hu3D6VLvb1 (SEQ ID NO:83)	Hu3D6VLvb2 (SEQ ID NO:84)	Hu3D6VLvb3 (SEQ ID NO:85)
L7	T	S	T	T	S	S
L10	T	S	T	T	S	S
L15	I	L	I	I	L	L
L17	Q	Q	Q	Q	Q	E
L24	K	R	K	K	K	R
L37	L	Q	L	L	L	Q
L45	K	R	K	K	K	R
L83	L	V	L	L	V	V
L86	H	Y	Y	H	Y	Y
L100	A	Q	G	A	A	Q
L106	L	I	I	L	I	I

[0343] Table 8: Percentage Humanness of Heavy and Light Chains of Humanized 3D6 Antibodies

V_H or V_L Variant	% Humanness
Hu3D6VHvb1 (SEQ ID NO:76)	65.3%
Hu3D6VHvb2 (SEQ ID NO:77)	76.5%
Hu3D6VHvb3 (SEQ ID NO:78)	81.6%
Hu3D6VHvb4 (SEQ ID NO:79)	83.7%
Hu3D6VHvb5 (SEQ ID NO:80)	85.7%
Hu3D6 VHvb6 (SEQ ID NO:90)	83.7%
Hu3D6 VHvb7 (SEQ ID NO:91)	84.7%
Hu3D6VLvb1 (SEQ ID NO:83)	82.0%
Hu3D6VLvb2 (SEQ ID NO:84)	87.0%
Hu3D6VLvb3 (SEQ ID NO:85)	89.0%

[0344] Positions at which canonical, vernier, or interface residues differ between mouse and human acceptor sequences are candidates for substitution. Examples of canonical/CDR interacting residues include Kabat residues H54 and H94 in Table 3. Examples of vernier residues include Kabat residues H28, H67, H93, and H94 in Table 3. Examples of interface/packing (VH+VL) residues include Kabat residues H91 and H93 in Table 3.

[0345] The rationales for selection of the positions indicated in Table 3 in the heavy chain variable region as candidates for substitution are as follows.

[0346] *heavy chain variable regions*

[0347] *hu3D6VHvb1*

- consists of the CDR-H1, H2, and H3 loops of 3D6-VH grafted onto the framework of 48G7-VH (RCS-VH), with backmutations at positions H91 (Y91F), H93 (A93S), and H94 (S94T).

[0348] *hu3D6VHvb2*

- reverts all framework substitutions at positions that are key for defining the Chothia canonical classes, are part of the Vernier zone, or localize to the VH/VL domain interface or contribute to structural stability. 3D6-VH_vb2 incorporates backmutations or substitutions Q1E, Q5V, L11V, L20I, T23K, K38R, E42G, Q43K, K66R, S75T, N76D, Q81E,Y91F, A93S, S94T T108L, and L109V, to enable assessment of these positions' contributions to antigen-binding affinity and immunogenicity.

[0349] *hu3D6VHvb3, hu3D6VHvb4, hu3D6VHvb5, hu3D6VHvb6, and hu3D6VHvb7* consists of further substitutions and either add to antibody stability and/or for optimization of glycosylation, aggregation, N-term heterogeneity, thermostability, surface exposed charged patches, surface exposed charge patches, deamination, and proteinase susceptibility.

[0350] Q1E: is a stability enhancing mutation to mitigate pyroglutamate formation potential (Liu, supra.) Q1E is a back-mutation.

[0351] Q5V: is a frequency-based and germ line-aligning mutation. Val is most frequent in human sequences at this position. Val is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0352] L11V: is a germ line-aligning mutation. Val is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0353] S17T: is a germ line-aligning mutation. Thr is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0354] L20I: is a germ line-aligning mutation. Ile is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0355] T23K: is a frequency-based and germ line-aligning mutation. Lys is more frequent at this position. Lys is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0356] N28T: This is a CDR-H1 residue substitution to Thr. N28T is a germ line-aligning mutation. Thr is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0357] K38R: is a frequency-based back-mutation. Arg is most frequent at this position. Arg at this position is predicted to make two H-bonds with Glu 46 in addition to one H-bond each with Asp86 and Tyr 90 in heavy chain; therefore, Arg substitution may enhance stability over Lys at this position.

[0358] E42G: is a frequency-based and germ line-aligning mutation. Gly is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position. Gly is most frequent at this position. Gly substitution is predicted not to affect stability.

[0359] Q43K: Lys side chain at this position is predicted to make H-bond with G42 besides main chain making H-bonds with Gln 39 and Arg 40, thereby Lys substitution may enhance stability over Q at this position. Q43K is a germ line-aligning mutation. Lys is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0360] N54D and D56E are substitutions of CDR residues and are predicted to be non-antigen contact positions as per homology model. N54D and D56E substitutions are predicted to stabilize antibody structure. N54D and D56E are germ line-aligning mutations. Asp is at position H54, and Glu is at position H56 in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25).

[0361] V58I: is a substitution of a CDR-H2 residue. Germline gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) has Ile at this position. This residue is predicted not to contact antigen.

[0362] K66R: Arg at this position is predicted to make H-bonds with Ser 82a and Thr 83 in addition to making H-bond and salt-bridge with Asp 86. K66R is a germ line-aligning mutation. Arg is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0363] A67V: is a substitution of a Vernier zone residue. Germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) has Val at this position.

[0364] S75T: Ser at this position is predicted to make H-bond with Asp 72 and Tyr 76. Thr at this position is predicted to also make these contacts but being surface exposed residue Thr may enhance antibody stability. S75T is a germ line-aligning mutation. Thr is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0365] N76D: Asp is a germ line-aligning mutation. Asp is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0366] L80M: Met is a germ line-aligning mutation. Met is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0367] Q81E: Glu is predicted to make H-bond plus salt-bridge with K19; hence Glu at this position enhances antibody stability. Q81E is a germ line-aligning mutation. Glu is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0368] T83R enhances thermostability and increases humanness. Arg is a germ-line aligning mutation. Arg is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ (ID NO: 25) at this position. Arg is most frequent at this position.

[0369] Y91F : is mutation of an interface residue, and is a back-mutation. Tyr at this position,may enhance antibody stability.

[0370] A93S: is a back-mutation of a Vernier zone and interface zone residue.

[0371] S94T: is a back-mutation of a Chothia defined canonical structural residue and vernier residue.

[0372] T108L: Leu is a germ line-aligning mutation. Leu is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position. Leu at this position is predicted to make the antibody less immunogenic and to have no impact on antibody stability.

[0373] L109V: is a frequency-based mutation. Val is most frequent at this position. L109V is a germ line-aligning mutation. Val is in human germ line gene IMGT# IGHV1-69-2*01 (SEQ ID NO:25) at this position.

[0374] The rationales for selection of the positions indicated in Table 4 in the light chain variable region as candidates for substitution are as follows.

[0375] *kappa light chain variable regions*

[0376] *hu3D6VLvb1*

- consists of the CDR-L1, L2, and L3 loops of 3D6-VL grafted onto the framework of ARX71335 VL.

[0377] *hu3D6VLvb2 and hu3D6VLvb3*

- reverts all framework substitutions at positions that are key for defining the Chothia canonical classes, are part of the Vernier zone, or locate to the VH/VL domain interface. Hu3D6-VLvb2 & Hu3D6-VLvb3 also include substitutions that contribute to structural stability; hu3D6-VL_vb2 incorporates backmutations T7S, I15L, L83V, H86Y and L106I, to enable assessment of these positions' contributions to antigen-binding affinity and immunogenicity.
  Hu3D6-VL_vb3 all substitutions mentioned for vb2 along with additional changes at Q17E, K24R, L37Q, K45R, and L106I

[0378] T7S: is a germ line-aligning mutation. Ser is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0379] T10S: is a frequency-based and germ line-aligning mutation. Ser is frequent at this position. Ser is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0380] I15L: is a germline-aligning mutation. Leu is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0381] Q17E: Glu at this position is predicted to make H-bond with T14 and salt-bridge with Lys 107, both light chain residues, and to enhance antibody stability.

[0382] K24R: is a mutation of a CDR residue. Both Lys and Arg are predicted to make H-bond and salt-bridge with Asp 70 in the light chain. Arg is predicted to fit better in the conformation. Arg is also a germ line-aligning mutation. Arg is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0383] L37Q: This is predicted to be a deep buried residue, Leu is not predicted to interact with surrounding residues, whereas, Gln is predicted to make H-bonds with Q38 and Asp 82 in the light chain. Gln is also a germ line-aligning mutation. Gln is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0384] K45R: Although Lys is predicted to make H-bonds with S56 and Gly 57; Arg's predicted interaction with neighboring residues is much more extensive as it is predicted to form salt-bridges with D55, H-bond with Arg46 and double H-bonds with S56. Arg is also a germ line-aligning mutation. Arg is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0385] L83V: This is a frequency-based mutation of a residue predicted to be surface exposed. Val is also a germ line-aligning mutation. Val is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0386] H86Y: Murine 3D6 VL has Tyr at this position. Tyr is also the most frequent residue at this position.

[0387] A100Q: Ala is rare at this position. Ala is predicted to be surface-exposed residue and is not predicted to interact surrounding residues. Gln is most frequent at this position. and is also a germline-aligning mutation. Gln is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position. Gln is predicted to make H-bond with Ser 7 stabilizing intra-chain.

[0388] L106I: is a frequency-based and germ line-aligning mutation. Ile is most frequent at this position. Ile is in human germ line gene IGKV2-30*02 (SEQ ID NO:27) at this position.

[0389] The designs based on these human frameworks were:

heavy chain variable regions

>hu3D6VHvb1 (SEQ ID NO:76)
QVQLQQSGAELVKPGASVKLSCTASGFNIKDYYLHWVKQRPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSSNTAYLQLSSLTSEDTAVYFCSTLDFWGQGTTLTVSS

>hu3D6VHvb2 (SEQ ID NO:77)
EVQLVQSGAEVVKPGASVKISCKASGFNIKDYYLHWVRQRPGKGLEWIGWIDPENGDT
VYDPKFQGRATITADTSTDTAYLELSSLTSEDTAVYFCSTLDFWGQGTLVTVSS

>hu3D6VHvb3 (SEQ ID NO:78)
EVQLVQSGAEVVKPGATVKISCKASGFNIKDYYLHWVRQRPGKGLEWIGWIDPENGDTI
YDPKFQGRATITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

hu3D6VHvb4 (SEQ ID NO:79)
EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPENGDTI
YDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

>hu3D6VHvb5 (SEQ ID NO:80)
EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGETI
YDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

>hu3D6VHvb6 (SEQ ID NO:90)
EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGET
VYDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYFCSTLDFWGQGTLVTVSS

>hu3D6VHvb7 (SEQ ID NO:91)
EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGET
VYDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

kappa light chain variable regions

hu3D6VLvb1 (SEQ ID NO:83)
DVVMTQTPLTLSVTIGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDLGVHYCWQGTHFPYTFGAGTKLELKR

>hu3D6VLvb2 (SEQ ID NO:84)
DVVMTQSPLSLSVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGAGTKLEIKR

>hu3D6VLvb3 (SEQ ID NO:85)
DVVMTQSPLSLSVTLGEPASISCRSSQSLLDSDGKTYLNWLQQRPGQSPRRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGQGTKLEIKR

[0390] Humanized sequences are generated using a two-stage PCR protocol that allows introduction of multiple mutations, deletions, and insertions using QuikChange site-directed mutagenesis [Wang, W. and Malcolm, B.A. (1999) BioTechniques 26:680-682).

[0391] **Example 4.** Mouse monoclonal antibodies bind tau in ELISA assays

[0392] Methods: Indirect ELISA: 96-well polystyrene plates were coated with capture antibodies anti-6xHis (Figure 3A) or polyclonal anti-tau (Dako #A0024, Figure 3B) suspended in 1xPBS for 2 hr at RT or 16 hr at 4°C. Coating was removed, and plates were blocked for 1 hr with 1%BSA in 1xPBS, followed by incubation with human recombinant tau, either with (Figure 3A) or without (Figure 3B) a polyhistidine tag at the N-terminus of the protein. After washing, plates were incubated with indicated antibodies, washed, and incubated with HRP-conjugated goat anti-mouse secondary antibody. Plates were developed with TMB, and A_{450} was measured with a plate reader.

[0393] Sandwich ELISA: 96-well polystyrene plates were coated with anti-mouse antibodies in 1xPBS for 2 hr at RT or 16 hr at 4°C. Coating was removed, and plates were blocked for 1 hr with 1%BSA in 1xPBS. The plate was next incubated with the Indicated antibodies at identical concentrations, diluted in 0.1% BSA in 1xPBS. Plates were successively treated with human tau, polyclonal rabbit anti-tau (Dako #A0024), and HRP-conjugated goat anti-rabbit antibody, all diluted in 0.1%BSA in PBS with washes occurring between each step. Streptavidin-HRP was added, plates were developed with TMB, and A_{450} was measured with a plate reader. See Figure 3C.

[0394] Results: A panel of hybridoma-produced antibodies were assayed for binding to tau via a number of different ELISA formats. Detection of tau was confirmed using an indirect format, using tau protein immobilized by its N-terminally fused polyhistidine tag (Figure 3A). Binding to the native, untagged protein was also confirmed (Figure 3B). To assess the solution affinity of the various antibodies, a sandwich ELISA format was used in which tested hybridoma antibodies were used as capture reagents (Figure 3C).

[0395] **Example 5.** Affinity of mouse monoclonal antibodies to tau

[0396] Methods: SPR analysis was performed using a Biacore T200 to determine the binding kinetics of murine antibodies to recombinant human tau. To prepare a sensor surface, anti-mouse antibody (GE Life Sciences) was immobilized on sensor chip CM5 via amine coupling, and antibody was captured at a level to ensure maximum binding of 50 RU. Various concentrations of recombinant tau ranging from 10-0.14 nM were passed over the captured ligand at a flow rate of 50 µL/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA), for 180 sec association and 900 sec dissociation. Data were double-referenced to both an irrelevant sensor not containing antibody ligand, and 0 nM analyte concentration to account for the dissociation of ligand from the capture moiety. Data was then analyzed using a global 1:1 fit.

[0397] Results: Multiple murine antibodies were selected based on their performance in a battery of ELISA assays, and their binding affinities were assessed via SPR. Antibodies were tested in parallel sets, and their binding association and dissociation rates were compared to select the highest binder to recombinant human tau. The highest binding affinity was observed with antibody clone 3D6. Binding affinities are shown in Figure 4.

[0398] **Example 6.** Mouse monoclonal antibodies prevent binding of human tau to the surface of immortalized neuronal cells

[0399] Methods: Inhibition_of Tau Binding to B103 Neuroblastoma Cells with anti-Tau Monoclonal Antibodies

1. Resuspend B103 cells in PBS at 5 x 10^5 cells/mL. Plate 50µL of cell suspension per well in a MSD High Bind plate. This results in 25K cells/well. Cover the plate and allow cells to attach at 37°C, 5% CO_2, for 2 hrs.

2. Following cell attachment, remove PBS from wells by inverting plate and gently tapping to remove excess buffer. Add 50µL of 3% MSD Blocker A in PBS or other suitable blocking buffer to each well and incubate plate at RT for 1 hr without shaking.

3. During the plate blocking step co-incubate Tau and anti-Tau antibodies as follows:

   a. Start with anti-Tau antibody at 2 mg/mL and serial dilute in PBS, 1:2, for 7 additional dilutions.

   b. Dilute Tau to 20 nM in PBS. The Tau concentration will be constant in each well.

c. Mix the Tau and anti-Tau antibody, 1:1, for a final Tau concentration of 10 nM and a starting concentration of anti-Tau of 1 mg/mL.

d. Incubate the mixture for approximately 1 hr at RT with shaking (600rpm).

4. After plate blocking, step 2, remove blocking buffer from wells by inverting plate and gently tapping and wash plate 2x with PBS using a multichannel pipette. Ensure excess buffer is completely removed. Cool the plated cells to 4°C prior to adding the Tau: anti-Tau complexes.

5. Add 50µL of cooled complex, step 3, to the plated cells and incubate on ice for 30 minutes.

6. Wash plate 2x with chilled PBS as previously described.

7. Add 50µL per well of the 16B5.SULFO-TAG for detection of cell surface bound Tau. Incubate for 30 minutes on ice.

8. Wash plate 2x with chilled PBS again as previously described.

9. Add 150 µL per well of 1X Read Buffer T Without Surfactant (diluted in H_2O) and read immediately on the MSD SECTOR™ 600 instrument. Avoid introducing bubbles when adding read buffer.

10. Report the MSD signals vs. concentration of anti-Tau.

[0400] Antibodies tested were anti-tau antibodies 3D6, 16G7, 3H9, 4C5, and 5G8, and isotype control.

[0401] Results:

[0402] Decreasing SulfoTag anti-tau signal occurring with increasing test antibody indicates functional blocking of the binding of tau to neuronal cell surfaces. No blocking was observed with isotype control, 16G7, or 3H9. Increasing amounts of functional blocking activity were observed with 4C5, 5G8, and 3D6. 3D6 demonstrated the deepest blocking activity of the antibodies tested. See Figure 5.

[0403] **Example 7.** Disaggregation activity

[0404] Methods: Aggregation of recombinant tau—Purified recombinant tau with an N-terminal 6xHis tag was combined with equimolar amounts of low-molecular weight heparin in 1xPBS (pH 7.4), and incubated at 37°C for 96 hr on a nutator. Aggregation of the sample was confirmed by binding to Thioflavin T.

Incubation with antibodies—Antibodies were incubated with aggregated, recombinant tau at the indicated molar ratios incubated at 37°C for 96 hr without rotation or nutation. At the end of the experiment, aggregation was measured by incubating samples with 25 mM Thioflavin T, and measuring emitted fluorescence (450/482 ex/em). Signals were background subtracted to buffer samples.

[0405] Results: As shown in Figure 6, 3D6 preferentially disassembles intact tau fibrils. Varying molar ratios of 3D6 (triangles), isotype control (circles) and 16G7 (squares) were incubated with amyloid-containing tau fibrils for 96 hours. At the end of this period, the extent of aggregation was assessed by binding to Thioflavin T. 3D6 preferentially decreases the Thioflavin T signal present in the sample, compared to both an isotype control antibody as well as to 16G7, an anti-tau antibody that binds to a different region of tau.

[0406] **Example 8.** 3D6 and 5G8 immunocapture tau from human disease tissue.

[0407] Methods: High-salt soluble protein fractions were prepared to 1 mg/ml. For each immunoprecipitation, 200 µg of sample was used. 10µg of the indicated antibody (either an isotype control, 3D6, or anti-tau antibody 5G8) was added to the high-salt sample preparations, and incubated for 2 hr. Protein G magnetic beads were then added to the mixtures, and incubated for a further hour to capture antibody/antigen complexes. Samples were thoroughly washed with 1xPBS, and beads were boiled in reducing/denaturing sample buffer to release captured proteins. Resulting samples were resolved by SDS-PAGE and Western blotting was performed using a polyclonal anti-tau antibody (Dako, #A0024).

[0408] Results: As shown in Figure 7, 3D6 and 5G8 immunoprecipitated tau from Alzheimer disease tissue. High-salt soluble fractions were immunoprecipitated with the indicated antibody, and detected with a polyclonal anti-tau antibody directed towards a separate region of the tau molecule from the binding sites for 3D6 and tau antibody A. 3D6 robustly captured tau from this fraction. The input (high-salt soluble sample) is shown at right.

[0409] **Example 9.** Immunohistochemistry immunoreactivity of 3D6,

[0410] Frontotemporal cortices were obtained from patients without neurodegenerative disease or with Alzheimer disease, which was confirmed upon post-mortem assessment. Immunohistochemistry was performed on lightly acetone-fixed, 10um slide-mounted cryosections. All staining steps were performed using a Leica BOND Rx autostainer, using Leica consumables. Either murine or a human form of 3D6 was incubated with tissue sections followed by addition of species-appropriate secondary antibodies conjugated to an HRP polymer. To prevent non-specific binding of endogenous immunoglobulin when using humanized antibodies on human tissue, the antibodies were non-covalently labeled with a biotin-conjugated anti-human monovalent Fab fragment in vitro before incubation on tissue. Tissue labeled with the primary antibody-biotin Fab fragment complex was further amplified using an avidin-biotin amplification system (Vector Laboratories, Burlingame, CA). The staining was visualized with a DAB chromogen, which produced a brown deposit. Negative control consisted of performing the entire immunohistochemical procedure on adjacent sections with an IgG isotype control antibody.

[0411] Antibodies tested were murine CD6, chimeric 3D6 (which contained VH and VL from the murine antibody with human constant regions, heavy chain SEQ ID NO:72 and light chain SEQ ID NO:73), and humanized variant hu3D6VHv5/hu3D6VLv2.

[0412] Staining performed with murine, chimeric, and humanized forms of 3D6 were qualitatively compared and assessed for the strength and intensity of staining, as well as localization of immunoreactivity. Intensity of staining was similar for chimeric and humanized forms of 3D6, and displayed similar localization patterns compared with the murine form of the antibody. Tau was detected in neurofibrillary tangles, fibrils, neuropil threads, and in degenerating axons. There was also notable somal staining detected.

[0413] **Example 10.** Affinity of humanized variants towards tau

[0414] Methods: Indirect ELISA 96-well polystyrene plates are coated with human recombinant tau suspended in 1xPBS for 2h at RT or 16h at 4°C. Coating is removed, and plates are blocked for 1h with 1%BSA in 1xPBS. Humanized variant antibodies at 1 µg/mL in 0.1% BSA in 1xPBS are added to plates for 1 hour followed by washing, and HRP-conjugated goat

anti-human antibody are added. Plates are developed with TMB, and A_{450} is measured with a plate reader.

[0415] Sandwich ELISA 96-well polystyrene plates are coated with anti-human antibodies in 1xPBS for 2 hr at RT or 16 hr at 4°C. Coating is removed, and plates are blocked for 1 hr with 1%BSA in 1xPBS. Humanized variant antibodies at varying concentrations diluted in 0.1% BSA in 1xPBS are added to plates for 1 hour followed by washing, and biotinylated recombinant human tau diluted in 0.1% BSA in 1xPBS is added. After washing, Streptavidin-HRP is added, plates are developed with TMB, and A_{450} is measured with a plate reader.

[0416] **Example 11.** Analysis of Humanized 3D6 Variants

[0417] Humanized 3D6 variants were analyzed for several characteristics, including target binding affinity, activity in cell-based assays, thermostability, expression titer, and presence of aggregation.

[0418] Plasmids were generated containing DNA encoding heavy chains hu3D6 VHvb1, h3D6VHvb2, hu3D6VHvb3, hu3D6VHvb4, hu3D6VHvb5, h3D6VHvb6 and h3D6VHvb7 and light chains hu3D6 VLvb1, hu3D6VLvb2, and hu3D6VLvb3. Different combinations of heavy and light chains were transiently expressed as intact antibodies in HEK-293 cells, and antibodies were purified from conditioned media using protein A chromatography. Purified antibodies were analyzed by size exclusion chromatography-high performance liquid chromatography (SEC-HPLC) to detect the presence of aggregation. Results are presented in Table 9, in column labeled "% Monomer."

[0419] Purified antibodies were analyzed by differential scanning calorimetry (DSC) to determine the thermostability of each variant. Thermostability values were determined using differential scanning calorimetry (DSC). All DSC scans were performed using a VP-Capillary DSC system (Malvern). All samples were prepared to 0.5 mg/mL in1xPBS and referenced to 1xPBS. Approximately 0.5 mL of protein solution and buffer were introduced into the sample and reference cell. Calorimetric scan rates were carried out at scan rates of 60°C/hour, from 25°C to 110°C under constant pressure. Analysis was performed using origin software. Reported values are the temperature at which the maximal heat capacity of the Fab peak is recorded. Results are presented in Table 9, in column labeled "Thermostability (°C)."

[0420] Titer was determined as follows. After expression in 293 suspension cells, antibodies were purified using Protein A chromatography utilizing standard methods. Following purification, the antibodies were exchanged into 1xPBS and protein concentrations were determined by absorbance at 280nm. Titers were calculated by dividing the final yield of purified protein by the starting volume of the expression culture, and reported in milligrams per liter. Results are presented in Table 9, in column labeled "Expression titer (mg/L)."

[0421] Affinity of purified humanized variants to tau were determined by surface plasmon resonance (SPR). SPR analysis was performed using a Biacore T200 to determine the binding kinetics of humanized antibodies to recombinant human tau. To prepare a sensor surface, anti-human antibody (GE Life Sciences) was immobilized on sensor chip CM3 via amine coupling, and antibody was captured at a level to ensure maximum binding of 50 RU. Various concentrations of recombinant tau ranging from 50-0.62 nM were passed over the captured ligand at a flow rate of 50 µL/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA), in a single cycle manner. Data were double-referenced to both an irrelevant sensor not containing antibody ligand, and 0 nM analyte concentration to account for the dissociation of ligand from the capture moiety. Data were then analyzed using a 1:1 fit. Results are presented in Table 9, in columns labeled "k_{on} ($M^{-1}s^{-1}$), k_{off} (s^{-1}), and K_d (nM)."

[0422] The ability of purified humanized variants to block internalization of tau was determined by cell internalization assays. An internalization assay employing fluorescence activated cell sorting (FACS) was performed to evaluate the ability of various antibodies to block neuronal internalization of tau. Antibodies that block internalization likely block transmission of tau. pHrodo-labeled 4R0N human tau P301L soluble oligomer (1.5 µg/mL final concentration) was preincubated with humanized variants (dose titration: 80 µg/mL starting concentration followed by 4-fold serial dilutions) for 30 min at room temperature in cell culture media. Tau/antibody mixture was then added to B103 neuroblastoma cell lines at 500,000 cells/ml final concentration and incubated for 3-4 hrs at 37°C in a tissue culture incubator (5% CO_2). Cells were then washed 3x with culture media, followed by 10 minutes culture media incubation, and washed 2x with FACS buffer (1% FBS in PBS). Cells were resuspended in 100 µL FACS buffer and Texas Red mean fluorescence intensity measured by FACS LSR II. Texas

red fluorescence from pHrodo is activated by low pH associated with endolysosomal compartments upon internalization. Because FACS detects cells and pHrodo only fluoresces upon internalization, only tau internalized by the cells is detected. The lower the mean fluorescence intensity, the lower the amount of internalized tau and higher blocking activity of the antibody tested. Results are presented in in Table 9.

Table 9. Biophysical/Expression Characteristics, Affinity, and Internalization Assay Results for 3D6 Humanized Variants

Antibody Name		Biophysical/Expression Characteristics			Affinity			
Heavy Chain	Light Chain	Thermostability (°C)	Expression titer (mg/L)	% Monomer	k_{on} ($M^{-1}s^{-1}$)	k_{off} (s^{-1})	K_d (nM)	Inhibition of cell based internalization (at 133 nM antibody concentration, % of inhibition of maximal fluorescent signal)
Hu3D6VHvb1 (SEQ ID NO:76)	Hu3D6VLvb1 (SEQ ID NO:83)	69.4	176	96	1.40E+06	9.00E-04	0.64	80.0
Hu3D6VHvb2 (SEQ ID NO:77)	Hu3D6VLvb2 (SEQ ID NO:84)	80.4	478	98	1.50E+06	5.70E-05	0.04	84.9
Hu3D6VHvb2 (SEQ ID NO:77)	Hu3D6VLvb3 (SEQ ID NO:85)	83.5	435	100	1.60E+06	3.00E-04	0.19	85.0
Hu3D6VHvb3 (SEQ ID NO:78)	Hu3D6VLvb2 (SEQ ID NO:84)	80.8	528	100	1.40E+06	1.50E-03	1.07	71.2
Hu3D6VHvb3 (SEQ ID NO:78)	Hu3D6VLvb3 (SEQ ID NO:85)	83.15	529	100	1.60E+06	1.80E-03	1.13	72.1
Hu3D6VHvb4 (SEQ ID NO:79)	Hu3D6VLvb2 (SEQ ID NO:84)	81.3	557	98	6.90E+05	2.90E-03	4.20	61.0
Hu3D6VHvb4 (SEQ ID NO:79)	Hu3D6VLvb3 (SEQ ID NO:85)	83.5	575	100	9.10E+05	3.40E-03	3.74	49.0
Hu3D6VHvb5 (SEQ ID NO:80)	Hu3D6VLvb2 (SEQ ID NO:84)	80.6	597	100	1.80E+06	2.60E-03	1.44	67.2
Hu3D6VHvb5 (SEQ ID NO:80)	Hu3D6VLvb3 (SEQ ID NO:85)	82.9	612	100	2.00E+06	2.80E-03	1.40	67.7
Hu3D6VHvb6 (SEQ ID NO:90)	Hu3D6VLvb2 (SEQ ID NO:84)	79.9	395	100	3.45E+06	3.69E-04	0.107	76.3
Hu3D6VHvb6 (SEQ ID NO:90)	Hu3D6VLvb3 (SEQ ID NO:85)	82.5	350	100	3.54E+06	5.38E-04	0.152	70.0
Hu3D6VHvb7 (SEQ ID NO:91)	Hu3D6VLvb2 (SEQ ID NO:84)	80.6	478	100	3.09E+06	7.79E-04	0.252	74.5

Antibody Name		Biophysical/Expression Characteristics	
Heavy Chain	Light Chain		
Hu3D6VHvb7 (SEQ ID NO:91)	Hu3D6VLvb3 (SEQ ID NO:85)	Thermostability (°C)	83.0
		Expression titer (mg/L)	447
		% Monomer	99
		Affinity	
		k_{on} ($M^{-1}s^{-1}$)	3.69E+06
		k_{off} (s^{-1})	7.70E-04
		K_d (nM)	0.209
		Inhibition of cell based internalization (at 133 nM antibody concentration, % of inhibition of maximal fluorescent signal)	66.0

Listing of Sequences

[0423] P10636-8 (SEQ ID NO:1)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKESPLQTPTEDGSE
EPGSETSDAKSTPTAEDVTAPLVDEGAPGKQAAAQPHTEIPEGTTAEEAGIGDTPSLEDE
AAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANATRIPAK
TPPAPKTPPSSGEPPKSGDRSGYSSPGSPGTPGSRSRTPSLPTPPTREPKKVAVVRTPPKSP
SSAKSRLQTAPVPMPDLKNVKSKIGSTENLKHQPGGGKVQIINKKLDLSNVQSKCGSKD
NIKHVPGGGSVQIVYKPVDLSKVTSKCGSLGNIHHKPGGGQVEVKSEKLDFKDRVQSKI
GSLDNITHVPGGGNKKIETHKLTFRENAKAKTDHGAEIVYKSPVVSGDTSPRHLSNVSST
GSIDMVDSPQLATLADEVSASLAKQGL

[0424] P10636-7 (SEQ ID NO:2)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKESPLQTPTEDGSE
EPGSETSDAKSTPTAEAEEAGIGDTPSLEDEAAGHVTQARMVSKSKDGTGSDDKKAKG
ADGKTKIATPRGAAPPGQKGQANATRIPAKTPPAPKTPPSSGEPPKSGDRSGYSSPGSPG
TPGSRSRTPSLPTPPTREPKKVAVVRTPPKSPSSAKSRLQTAPVPMPDLKNVKSKIGSTEN
LKHQPGGGKVQIINKKLDLSNVQSKCGSKDNIKHVPGGGSVQIVYKPVDLSKVTSKCGS
LGNIHHKPGGGQVEVKSEKLDFKDRVQSKIGSLDNITHVPGGGNKKIETHKLTFRENAK
AKTDHGAEIVYKSPVVSGDTSPRHLSNVSSTGSIDMVDSPQLATLADEVSASLAKQGL

[0425] P10636-6 (4RON human tau) (SEQ ID NO:3)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKAEEAGIGDTPSLE
DEAAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANATRIP
AKTPPAPKTPPSSGEPPKSGDRSGYSSPGSPGTPGSRSRTPSLPTPPTREPKKVAVVRTPPK
SPSSAKSRLQTAPVPMPDLKNVKSKIGSTENLKHQPGGGKVQIINKKLDLSNVQSKCGS
KDNIKHVPGGGSVQIVYKPVDLSKVTSKCGSLGNIHHKPGGGQVEVKSEKLDFKDRVQ
SKIGSLDNITHVPGGGNKKIETHKLTFRENAKAKTDHGAEIVYKSPVVSGDTSPRHLSNV
SSTGSIDMVDSPQLATLADEVSASLAKQGL

[0426] P10636-5 (SEQ ID NO:4)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKESPLQTPTEDGSE
EPGSETSDAKSTPTAEDVTAPLVDEGAPGKQAAAQPHTEIPEGTTAEEAGIGDTPSLEDE
AAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANATRIPAK
TPPAPKTPPSSGEPPKSGDRSGYSSPGSPGTPGSRSRTPSLPTPPTREPKKVAVVRTPPKSP
SSAKSRLQTAPVPMPDLKNVKSKIGSTENLKHQPGGGKVQIVYKPVDLSKVTSKCGSLG
NIHHKPGGGQVEVKSEKLDFKDRVQSKIGSLDNITHVPGGGNKKIETHKLTFRENAKAK
TDHGAEIVYKSPVVSGDTSPRHLSNVSSTGSIDMVDSPQLATLADEVSASLAKQGL

[0427] P10636-4 (SEQ ID NO:5)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKESPLQTPTEDGSE
EPGSETSDAKSTPTAEAEEAGIGDTPSLEDEAAGHVTQARMVSKSKDGTGSDDKKAKG
ADGKTKIATPRGAAPPGQKGQANATRIPAKTPPAPKTPPSSGEPPKSGDRSGYSSPGSPG
TPGSRSRTPSLPTPPTREPKKVAVVRTPPKSPSSAKSRLQTAPVPMPDLKNVKSKIGSTEN
LKHQPGGGKVQIVYKPVDLSKVTSKCGSLGNIHHKPGGGQVEVKSEKLDFKDRVQSKI
GSLDNITHVPGGGNKKIETHKLTFRENAKAKTDHGAEIVYKSPVVSGDTSPRHLSNVSST
GSIDMVDSPQLATLADEVSASLAKQGL

[0428] P10636-2 (SEQ ID NO:6)

MAEPRQEFEVMEDHAGTYGLGDRKDQGGYTMHQDQEGDTDAGLKAEEAGIGDTPSLE
DEAAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANATRIP
AKTPPAPKTPPSSGEPPKSGDRSGYSSPGSPGTPGSRSRTPSLPTPPTREPKKVAVVRTPPK
SPSSAKSRLQTAPVPMPDLKNVKSKIGSTENLKHQPGGGKVQIVYKPVDLSKVTSKCGS
LGNIHHKPGGGQVEVKSEKLDFKDRVQSKIGSLDNITHVPGGGNKKIETHKLTFRENAK
AKTDHGAEIVYKSPVVSGDTSPRHLSNVSSTGSIDMVDSPQLATLADEVSASLAKQGL

[0429] SEQ ID NO:7; Murine 3D6 VH amino acid sequence:

EVQLQQSGADLVRPGALVKLSCKASGFNIKDYYLHWVRQRPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSSNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTTLTVSS

[0430] SEQ ID NO:8; Kabat/Chothia HCDR1:

GFNIKDYYLH

[0431] SEQ ID NO:9; Kabat HCDR2:

WIDPENGDTVYDPKFQG

[0432] SEQ ID NO:10; Kabat HCDR3:

LDF

[0433] SEQ ID NO:11; Murine 3D6 VL amino acid sequence:

DVVMTQTPLTLSVTIGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFTGSGSGTDFTLKISRVEAEDLGVYYCWQGTHFPYTFGGGTKLEIKR

[0434] SEQ ID NO:12; Murine Kabat LCDR1:

KSSQSLLDSDGKTYLN

[0435] SEQ ID NO:13; Murine Kabat LCDR2:

LVSKLDS

[0436] SEQ ID NO:14; Murine Kabat LCDR3:

WQGTHFPYT

[0437] SEQ ID NO:15; hu3D6VHv1:

EVQLVQSGAEVVRPGALVKVSCKASGFNIKDYYLHWVRQAPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSTNTAYLQLSSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0438] SEQ ID NO:16; hu3D6VHv2:

EVQLVQSGAEVKKPGASVKVSCKVSGFNIKDYYLHWVRQAPEQGLEWMGWIDPENGD
TVYDPKFQGRVTITADTSTNTAYMELSSLTSEDTAVYYCSTLDFWGQGTLVTVSS

[0439] SEQ ID NO:17; hu3D6VHv1b:

EVQLVQSGAEVVRPGALVKISCKASGFNIKDYYLHWVRQRPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSTNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0440] SEQ ID NO:18; hu3D6VHv1bA11:

EVQLVQSGAEVVKPGATVKISCKASGFNIKDYYLHWVRQRPGQGLEWIGWIDPENGDT
VYDPKFQGRATITADTSTDTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0441] SEQ ID NO:19; hu3D6VHv5:

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGQGLEWIGWIDPEDGDT VYAPKFQGRATITADTSTDTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0442] SEQ ID NO:20; hu3D6VLv1:

DVVMTQSPLSLSVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGGGTKLEIKR

[0443] SEQ ID NO:21; hu3D6VLv2:

DVVMTQSPLSLPVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPRRLIYLVSKLD SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGGGTKLEIKR

[0444] SEQ ID NO:22; hu3D6VLv3:

DVVMTQSPLSLPVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPRRLIYLVSKLD SGVPSRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGGGTKLEIKR

[0445] SEQ ID NO:23; hu3D6VLv4:

DIVMTQTPLSLSVTIGQPASISCKSSQSLLDSDGKTYLNWLLQKPGQSPKRLIYLVSKLDS GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGGGTKLEIKR

[0446] SEQ ID NO:24 ; heavy chain variable acceptor Acc.# BAC01986.1

QVQLQQSGAEVKKPGSSVKVSCKASGGTFGSYAISWVRQAPGQGLEWMGRIIPILGIAT YAQKFQGRVTITADKSTSTAYMDLSSLRSEDTAVYYCARGKGEFEGMDVWGQGTTVT VSS

[0447] SEQ ID NO:25 ; heavy chain variable acceptor Acc.# IMGT# IGHV1-69-2*01

EVQLVQSGAEVKKPGATVKISCKVSGYTFTDYYMHWVQQAPGKGLEWMGLVDPEDG ETIYAEKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCAT

[0448] SEQ ID NO:26 ; heavy chain variable acceptor Acc.# IMGT#IGKJ1*01

QHWGQGTLVTVSS

[0449] SEQ ID NO:27; light chain variable acceptor Acc. # IMGT#IGKV2-30*02 Acc. # IMGT#IGKV2-30*02

DVVMTQSPLSLPVTLGQPASISCRSSQSLVHSDGNTYLNWFQQRPGQSPRRLIYKVSNRD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCMQGTHWP

[0450] SEQ ID NO:28 ; light chain variable acceptor Acc. # IMGT#IGKJ2*01

YTFGQGTKLEIK

[0451] SEQ ID NO:29; Light chain variable acceptor Acc. # AAZ09048.1

DVVMTQSPLSLTVTLGQPASISCRSSQSLVYSDGNTYLNWFQQRPGQSPRRLIYRVSHW
DSGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCMQGTYWPLTFGQGTKLEIK

[0452] SEQ ID NO:30 ; Murine 3D6 VH nucleic acid sequence:

GAGGTTCAGCTGCAGCAGTCTGGGGCTGACCTTGTGAGGCCAGGGGCCTTAGTCAA
GTTGTCCTGCAAAGCTTCTGGCTTCAACATTAAAGACTACTATTTGCACTGGGTGAG
GCAGAGGCCTGAACAGGGCCTGGAGTGGATTGGATGGATTGATCCTGAGAATGGTG
ATACTGTATATGACCCGAAGTTCCAGGGCAAGGCCACTATAACAGCAGACACATCC
TCCAATACAGCCTACCTGCAGCTCGGCAGCCTGACATCTGAGGACACTGCCGTCTAT
TTCTGTTCTACCCTTGACTTCTGGGGCCAAGGCACCACTCTCACAGTCTCCTCA

[0453] SEQ ID NO:31; Murine 3D6 VL nucleic acid sequence:

GATGTTGTGATGACCCAGACTCCACTCACTTTGTCGGTTACCATTGGACAACCAGCC
TCCATCTCTTGCAAGTCAAGTCAGAGCCTCTTAGATAGTGATGGAAAGACATATTTG
AATTGGTTGTTACAGAGGCCAGGCCAGTCTCCAAAGCGCCTAATCTATCTGGTGTCT
AAACTGGACTCTGGAGTCCCTGACAGGTTCACTGGCAGTGGATCAGGGACAGATTTC
ACACTGAAAATCAGCAGAGTGGAGGCTGAGGATTTGGGAGTTTATTATTGCTGGCA
AGGTACACATTTTCCGTACACGTTCGGAGGGGGGACCAAGCTGGAAATAAAACGT

[0454] SEQ ID NO:32; Murine CDR-H1 Kabat

DYYLH

[0455] SEQ ID NO:33; Murine CDR-H1 Chothia

GFNIKDY

[0456] SEQ ID NO:34; Murine CDR-H2 Chothia

DPENGD

[0457] SEQ ID NO:35; Murine CDR-H2 AbM

WIDPENGDTV

[0458] SEQ ID NO:36; Murine CDR-L1 Contact

KTYLNWL

[0459] SEQ ID NO:37; Murine CDR-L2 Contact

RLIYLVSKLD

[0460] SEQ ID NO:38; Murine CDR-L3 Contact

WQGTHFPY

[0461] SEQ ID NO:39; Murine CDR-H1 Contact

KDYYLH

[0462] SEQ ID NO:40; Murine CDR-H2 Contact

WIGWIDPENGDTV

[0463] SEQ ID NO:41; Murine CDR-H3 Contact

STLD

[0464] SEQ ID NO:42; Alternate Kabat-Chothia CDR-H1

GFTIKDYYLH

[0465] SEQ ID NO:43; Alternate Kabat CDR-H2

WIDPEDGDTVYAPKFQG

[0466] SEQ ID NO:44; consensus VH amino acid sequence from Figure 2 of PCT/IB2017/052544

EVQLVQSGAEVVXPGALVKISCKASGFNIKDYYLHWVRQRPEQGLEWIGWIDPENGDT VYDPKFQGXATITADTSTNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0467] SEQ ID NO:45; consensus VL amino acid sequence of Figure 3 of PCT/IB2017/052544

DVVMTQSPLSLSVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGGGTKLEIKR

[0468] SEQ ID NO:46; hu3D6VHv1bA11B6G2:

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWVDPEDGDT
VYAPKFQGRATITADTSTDTAYLELGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0469] SEQ ID NO:47; hu3D6VHv1bA11B6H3:

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGDT
VYAPKFQGRATITADTSTDTAYLELGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0470] SEQ ID NO:48; hu3D6VHv1c:

EVQLVQSGAEVKRPGALVKISCKASGFNFKDYYLHWVRQRPEQGLEWMGWIDPENGD
TVYDEKFQGRVTITADTSTNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0471] SEQ ID NO:49; hu3D6VHv1d:

EVQLVQSGAEVKRPGALVKISCKASGYTFTDYYLHWVRQRPEQGLEWMGWVDPEDGD
TVYAEKFQGRVTITADTSTNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0472] SEQ ID NO:50; hu3D6VHv1e:

EVQLVQSGADVVKPGALVKISCKASGFTIKDYYLHWVRQRPEQGLEWIGWIDPENGDT
VYAEKFQGRVTITADTSTNTAYLELGSLTSEDTAVYFCSTLDFWGQGTTLTVSS

[0473] SEQ ID NO:51; hu3D6VHv1f:

EVQLVQSGADVVKPGALVKISCKASGFTIKDYYLHWVRQRPGQGLEWIGWVDPEDGD
TVYAEKFQGRVTITADTSTDTAYMELGSLTSEDTAVYFCSTLDYWGQGTTLTVSS

[0474] SEQ ID NO:52; hu3D6VHv3:

EVQLVQSGAEVKKPGATVKISCKVSGFNIKDYYLHWVRQAPGKGLEWMGWIDPENGD
TVYDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0475] SEQ ID NO:53; hu3D6VHv3b:

EVQLVQSGAEVKKPGALVKISCKVSGYNFKDYYLHWVRQAPGKGLEWMGWIDPENG
DTVYDEKFQGRVTITADTSTNTAYMELGSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0476] SEQ ID NO:54; hu3D6VHv3c:

EVQLVQSGAEVKKPGALVKISCKVSGYTFTDYYLHWVRQAPGKGLEWMGWVDPEDG
DTVYAEKFQGRVTITADTSTNTAYMELGSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0477] SEQ ID NO:55; hu3D6VHv4:

EVQLVQSGAEVVKPGATVKISCKVSGFNIKDYYLHWVRQRPGKGLEWIGWIDPENGDT
VYDPKFQGKATITADTSTNTAYLELGSLTSEDTAVYYCSTLDFWGQGTLVTVSS

[0478] SEQ ID NO:56; hu3D6VHv4b:

EVQLVQSGAEVVKPGALVKISCKVSGYNFKDYYLHWVRQRPGKGLEWMGWIDPENGD
TVYDEKFQGRVTITADTSTDTAYLELGSLTSEDTAVYYCSTLDFWGQGTLVTVSS

[0479] SEQ ID NO:57; hu3D6VHv4c:

EVQLVQSGAEVVKPGALVKISCKVSGYTFTDYYLHWVRQRPGKGLEWMGWVDPEDG
DTVYAEKFQGRVTITADTSTDTAYLELGSLTSEDTAVYYCSTLDFWGQGTLVTVSS

[0480] SEQ ID NO:58; Alternate Kabat-Chothia CDR-H1 (as in hu3D6VH1c).

GFNFKDYYLH

[0481] SEQ ID NO:59; Alternate Kabat-Chothia CDR-H1, (as in hu3D6VHv1d, hu3D6VHv3c, and hu3D6VHv4c).

GYTFTDYYLH

[0482] SEQ ID NO:60; Alternate Kabat-Chothia CDR-H1 (as in hu3D6VHv3b and hu3D6VHv4b)

GYNFKDYYLH

[0483] SEQ ID NO:61; Alternate Kabat CDR-H2 (as in hu3D6VHv1bA11B6G2).

WVDPEDGDTVYAPKFQG

[0484] SEQ ID NO:62, Alternate Kabat CDR-H2 (as in hu3D6VHv1c, hu3D6VHv3b, AND hu3D6VHv4b.

WIDPENGDTVYDEKFQG

[0485] SEQ ID NO:63; Alternate Kabat CDR-H2 as in hu3D6VHv1d, hu3D6VHv1f, hu3D6VHv3c, and hu3D6VHv4c).

WVDPEDGDTVYAEKFQG

[0486] SEQ ID NO:64; Alternate Kabat CDR-H2 (as in hu3D6VHv1e).

WIDPENGDTVYAEKFQG

[0487] SEQ ID NO:65; Alternate Kabat CDR-H3 (as in hu3D6VHv1f)

LDY

[0488] SEQ ID NO:66; heavy chain variable region of the mouse 6A10 antibody.

EVQLQQSGAELVRSGASVKLSCTASGLNIKDYYIHWVKQRPEQGLEWIGWIDPENDDTE
YAPKFQGRATLTTDTSSNTAYLQLSSLTSEDTAVYYCTPLDYWGQGTSVTVSS

[0489] SEQ ID NO:67; Kabat/Chothia composite CDR-H1 of the mouse 6A10 antibody.

GLNIKDYYIH

[0490] SEQ ID NO:68; Kabat CDR-H2 of the mouse 6A10 antibody.

WIDPENDDTEYAPKFQG

[0491] SEQ ID NO:69; Kabat CDR-H3 of the mouse 6A10 antibody

LDY

[0492] SEQ ID NO:70; Mus VH structure template (PDB#1CR9_H)

KVKLQQSGAELVRSGASVKLSCTASGFNIKDYYIQWVKQRPEQGLEWIGWIDPENGNSEYAPRF
QGKATMTADTLSNTAYLQLSSLTSEDTAVYYCNADLHDYWGQGTTLTVSS

[0493] SEQ ID NO:71; consensus VH amino acid sequence from Figures 4A and 4B of PCT/IB2017/052544

EVQLVQSGAEVVKPGALVKISCKASGFNIKDYYLHWVRQRPGQGLEWIGWIDPENGDT
VYDPKFQGRVTITADTSTNTAYLELGSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0494] SEQ ID NO:72; heavy chain of chimeric 3D6 antibody

EVQLQQSGADLVRPGALVKLSCKASGFNIKDYYLHWVRQRPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSSNTAYLQLGSLTSEDTAVYFCSTLDFWGQGTTLTVSSASTKG
PSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL
SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFL
FPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTY
RVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMT
KNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQ
QGNVFSCSVMHEALHNHYTQKSLSLSPGK

[0495] SEQ ID NO:73; light chain of chimeric 3D6 antibody

DVVMTQTPLTLSVTIGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFTGSGSGTDFTLKISRVEAEDLGVYYCWQGTHFPYTFGGGTKLEIKRTVAAPS
VFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSTY
SLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

[0496] SEQ ID NO:74; amino acid sequence of heavy chain variable structural model Acc.# 5MYX-VH_mSt

EVQLQQSGAELVRPGSSVKISCKASGYIFNNYWINWVKQRPGQGLEWIGQIYPGDGDTN
YNGKFKGKATLTADKSSSTAYMQLSSLTSEDSAVYFCAREGYIVYWGQGTLVTVSA

[0497] SEQ ID NO:75; amino acid sequence of heavy chain variable acceptor Acc.# 2RCS-VH_huFrwk

QVQLQQSGAELVKPGASVKLSCTASGFNIKDTYMHWVKQRPEQGLEWIGRIDPANGNT
KYDPKFQGKATITADTSSNTAYLQLSSLTSEDTAVYYCASYYGIYWGQGTTLTVSS

[0498] SEQ ID NO:76; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb1

QVQLQQSGAELVKPGASVKLSCTASGFNIKDYYLHWVKQRPEQGLEWIGWIDPENGDT
VYDPKFQGKATITADTSSNTAYLQLSSLTSEDTAVYFCSTLDFWGQGTTLTVSS

[0499] SEQ ID NO:77; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb2

EVQLVQSGAEVVKPGASVKISCKASGFNIKDYYLHWVRQRPGKGLEWIGWIDPENGDT
VYDPKFQGRATITADTSTDTAYLELSSLTSEDTAVYFCSTLDFWGQGTLVTVSS

[0500] SEQ ID NO:78; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb3

EVQLVQSGAEVVKPGATVKISCKASGFNIKDYYLHWVRQRPGKGLEWIGWIDPENGDTI
YDPKFQGRATITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0501] SEQ ID NO:79; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb4

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPENGDTI
YDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0502] SEQ ID NO:80; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb5

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGETI
YDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0503] SEQ ID NO:81; amino acid sequence of light chain variable structural model Acc.# 5MYX-VL_mSt

DVVLTQTPLTLSVTIGQPASISCKSSQSLLYSNGKTYLNWLLQRPGQSPKRLIYVVSKLDS
GVPDRFTGSGSGTDFTLKISRVEAEDLGVYYCVQGTHFPFTFGSGTKLEIK

[0504] SEQ ID NO:82; amino acid sequence of light chain variable acceptor Acc.# ARX71335-VL_huFrwk

DVVMTQTPLTLSVTIGQPASISCKSSQSLLYSNGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDLGVHYCEQGTHFPLTFGAGTKLELK

[0505] SEQ ID NO:83; amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb1

DVVMTQTPLTLSVTIGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDLGVHYCWQGTHFPYTFGAGTKLELKR

[0506] SEQ ID NO:84; amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb2

DVVMTQSPLSLSVTLGQPASISCKSSQSLLDSDGKTYLNWLLQRPGQSPKRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGAGTKLEIKR

[0507] SEQ ID NO:85; amino acid sequence of light chain variable region of the humanized 3D6 antibody hu3D6VLvb3

DVVMTQSPLSLSVTLGEPASISCRSSQSLLDSDGKTYLNWLQQRPGQSPRRLIYLVSKLD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCWQGTHFPYTFGQGTKLEIKR

[0508] SEQ ID NO:86; amino acid sequence of an alternate Kabat-Chothia Composite CDR-H1 of a humanized 3D6 antibody (as in hu3D6VHvb4 and hu3D6VHvb5)

GFTIKDYYLH

[0509] SEQ ID NO:87; amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb3 and hu3D6VHvb4)

WIDPENGDTIYDPKFQG

[0510] SEQ ID NO:88; amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb5)

WIDPEDGETIYDPKFQG

[0511] SEQ ID NO:89; amino acid sequence of an alternate Kabat CDR-L1 of a humanized 3D6 antibody (as in hu3D6VLvb3)

RSSQSLLDSDGKTYLN

[0512] SEQ ID NO:90; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb6

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGET
VYDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYFCSTLDFWGQGTLVTVSS

[0513] SEQ ID NO:91; amino acid sequence of heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb7

EVQLVQSGAEVVKPGATVKISCKASGFTIKDYYLHWVRQRPGKGLEWIGWIDPEDGET
VYDPKFQGRVTITADTSTDTAYMELSSLRSEDTAVYYCSTLDFWGQGTLVTVSS

[0514] SEQ ID NO:92; amino acid sequence of an alternate Kabat CDR-H2 of a humanized 3D6 antibody (as in hu3D6VHvb6 and hu3D6VHvb7)

WIDPEDGETVYDPKFQG

[0515] SEQ ID NO:93; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb1

CAAGTGCAGCTGCAGCAGAGCGGGGCAGAATTGGTCAAGCCCGGAGCGTCAGTGAA
GCTGAGCTGCACCGCCTCCGGCTTCAACATCAAAGACTACTATCTTCACTGGGTCAA
GCAACGGCCTGAACAGGGCCTGGAGTGGATTGGTTGGATCGACCCAGAAAACGGCG
ACACCGTGTACGATCCGAAGTTTCAGGGGAAGGCCACCATCACTGCTGATACGTCCT
CGAACACCGCCTACCTCCAACTGAGCTCCCTGACTTCCGAGGACACTGCCGTGTACT
TCTGTTCCACCCTGGACTTCTGGGGACAGGGAACTACCCTCACCGTGTCCTCGGCCA
GCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTG
GAACCGCGGCACTGGGGTGCCTCG

[0516] SEQ ID NO:94; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb2

GAAGTGCAGCTCGTGCAGTCCGGTGCCGAAGTCGTGAAACCGGGAGCCAGCGTGAA
GATTAGCTGCAAGGCCTCAGGGTTCAACATCAAGGACTATTACCTTCACTGGGTCAG
ACAGCGGCCTGGAAAGGGCTTGGAGTGGATCGGATGGATTGACCCCGAGAACGGCG
ACACCGTGTACGATCCGAAGTTTCAGGGCCGCGCAACCATCACTGCTGACACCTCCA
CCGATACCGCGTACCTGGAACTCTCGAGCCTGACTTCCGAGGATACGGCCGTGTACT
TCTGTTCCACCCTGGACTTCTGGGGACAAGGGACTCTGGTCACCGTGTCCTCGGCCA
GCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTG
GAACCGCGGCACTGGGGTGCCTCG

[0517] SEQ ID NO:95; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb3

GAGGTGCAACTGGTGCAGTCCGGAGCCGAAGTCGTGAAGCCGGGAGCCACCGTGAA
GATTTCGTGCAAAGCGTCAGGGTTTAACATCAAGGACTACTATCTGCACTGGGTCCG
CCAGAGGCCCGGGAAGGGCCTCGAGTGGATCGGTTGGATCGACCCTGAAAACGGCG
ACACCATCTACGATCCAAAGTTCCAGGGCAGAGCCACTATTACCGCTGACACGAGC
ACCGATACTGCATACATGGAATTGTCCTCCCTGCGGTCCGAGGATACTGCCGTGTAC
TACTGTAGCACCCTGGACTTCTGGGGACAGGGAACCCTTGTGACCGTGTCGTCCGCC
AGCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGT
GGAACCGCGGCACTGGGGTGCCTCG

[0518] SEQ ID NO:96; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb4

GAGGTGCAGCTCGTGCAGTCCGGTGCTGAAGTCGTGAAGCCCGGCGCAACTGTGAA
GATTAGCTGCAAGGCCTCAGGGTTCACGATCAAGGACTACTATCTGCACTGGGTCCG
CCAACGGCCAGGAAAGGGACTGGAGTGGATCGGATGGATCGATCCTGAAAACGGCG
ACACCATCTACGACCCGAAATTTCAGGGGAGAGTGACCATTACCGCCGATACCTCC
ACCGACACTGCGTACATGGAACTGTCCAGCCTTCGGTCCGAGGACACCGCCGTGTAC
TACTGTTCGACCCTGGATTTCTGGGGACAGGGCACTCTCGTGACTGTGTCGTCCGCC
AGCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGT
GGAACCGCGGCACTGGGGTGCCTCG

[0519] SEQ ID NO:97; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb5

GAAGTGCAACTGGTGCAGTCCGGCGCAGAAGTCGTGAAGCCTGGAGCCACCGTGAA
GATCAGCTGCAAGGCCTCCGGCTTCACCATCAAAGACTACTACTTGCACTGGGTCAG
ACAGCGCCCAGGAAAGGGTCTGGAATGGATTGGATGGATTGACCCCGAGGACGGGG
AGACTATCTACGATCCGAAGTTTCAGGGCCGGGTCACCATCACGGCTGATACCTCGA
CCGACACTGCGTACATGGAACTTTCCTCGCTGCGGTCCGAGGACACCGCCGTGTATT
ACTGTTCCACCCTGGATTTCTGGGGACAGGGGACTCTCGTGACTGTGTCAAGCGCCA
GCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTG
GAACCGCGGCACTGGGGTGCCTCG

[0520] SEQ ID NO:98; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb6

GAAGTGCAACTGGTGCAGTCCGGCGCAGAAGTCGTGAAGCCTGGAGCCACCGTGAA
GATCAGCTGCAAGGCCTCCGGCTTCACCATCAAAGACTACTACTTGCACTGGGTCAG
ACAGCGCCCAGGAAAGGGTCTGGAATGGATTGGATGGATTGACCCCGAGGACGGGG
AGACTGTGTACGATCCGAAGTTTCAGGGCCGGGTCACCATCACGGCTGATACCTCGA
CCGACACTGCGTACATGGAACTTTCCTCGCTGCGGTCCGAGGACACCGCCGTGTATT
TCTGTTCCACCCTGGATTTCTGGGGACAGGGGACTCTCGTGACTGTGTCAAGCGCCA
GCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTG
GAACCGCGGCACTGGGGTGCCTCG

[0521] SEQ ID NO:99; a nucleic acid sequence encoding the heavy chain variable region of the humanized 3D6 antibody hu3D6VHvb7

GAAGTGCAACTGGTGCAGTCCGGCGCAGAAGTCGTGAAGCCTGGAGCCACCGTGAA
GATCAGCTGCAAGGCCTCCGGCTTCACCATCAAAGACTACTACTTGCACTGGGTCAG
ACAGCGCCCAGGAAAGGGTCTGGAATGGATTGGATGGATTGACCCCGAGGACGGGG
AGACTGTGTACGATCCGAAGTTTCAGGGCCGGGTCACCATCACGGCTGATACCTCGA
CCGACACTGCGTACATGGAACTTTCCTCGCTGCGGTCCGAGGACACCGCCGTGTATT
ACTGTTCCACCCTGGATTTCTGGGGACAGGGGACTCTCGTGACTGTGTCAAGCGCCA
GCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCGGGTG
GAACCGCGGCACTGGGGTGCCTCG

[0522] SEQ ID NO:100; a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb1

GATGTCGTGATGACCCAGACGCCGCTGACCCTGTCCGTGACTATCGGCCAGCCCGCG
TCCATTTCGTGCAAGAGCAGCCAGTCCCTGCTGGACTCCGACGGAAAGACCTACCTG
AACTGGCTGTTGCAACGGCCGGGACAGTCACCCAAGCGCCTCATCTATCTGGTGTCC
AAGCTCGACTCGGGAGTGCCTGATAGGTTTTCGGGATCCGGCAGCGGGACCGACTTC
ACCCTGAAAATCTCAAGAGTGGAAGCCGAGGACCTTGGTGTCCATTACTGTTGGCAG
GGTACCCACTTCCCATACACTTTCGGGGCCGGCACTAAGCTCGAACTGAAG

[0523] SEQ ID NO:101; a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb2

GATGTCGTGATGACCCAGTCGCCGCTGTCCCTGTCCGTGACCCTGGGACAGCCAGCC
TCCATTAGCTGCAAGAGCAGCCAGTCCTTGCTGGACTCAGACGGAAAGACCTATCTG
AACTGGCTGCTGCAAAGGCCCGGCCAGTCCCCGAAGAGACTCATCTACCTCGTGTCG
AAGCTGGACTCCGGCGTGCCTGATCGCTTCTCGGGTTCCGGGTCTGGAACTGACTTC
ACCCTCAAAATCTCACGGGTCGAAGCCGAGGACGTGGGCGTGTACTACTGTTGGCA
GGGTACCCACTTTCCCTACACTTTCGGGGCGGGAACTAAGCTTGAGATCAAG

[0524] SEQ ID NO:102; a nucleic acid sequence encoding the light chain variable region of the humanized 3D6 antibody hu3D6VLvb3

GATGTCGTGATGACCCAGAGCCCCCTGTCCCTGAGCGTGACTCTGGGGGAACCGGC
CAGCATTTCATGCCGGTCCTCACAATCGCTGCTCGACTCCGACGGAAAGACCTATTT
GAACTGGCTGCAGCAAAGACCAGGACAGTCCCCTCGCCGGCTCATCTACCTGGTGTC
CAAGCTTGACTCGGGCGTGCCGGATAGGTTCTCCGGGTCCGGAAGCGGCACCGACT
TCACTCTGAAAATCTCGCGCGTGGAAGCCGAGGACGTGGGAGTCTACTACTGTTGGC
AGGGTACCCACTTCCCCTACACGTTTGGCCAGGGTACCAAGCTCGAGATCAAG

[0525] SEQ ID NO:103; amino acid sequence of an exemplary IgG1 heavy chain constant region

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQY
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSR
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDK
SRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

[0526] SEQ ID NO:104; amino acid sequence of an exemplary kappa light chain constant region

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQ
DSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

[0527] SEQ ID NO:105; a nucleic acid sequence encoding an exemplary IgG1 heavy chain constant region

GCCAGCACTAAGGGGCCTAGCGTCTTTCCGCTGGCCCCGTCCTCCAAGTCCACTTCG
GGTGGAACCGCGGCACTGGGGTGCCTCGTGAAGGACTACTTCCCCGAGCCGGTCAC
CGTGTCCTGGAACTCGGGAGCCCTGACCTCCGGAGTGCATACTTTCCCTGCGGTGCT
GCAGTCCTCCGGGCTCTACTCGCTGTCAAGCGTGGTCACCGTCCCGAGCTCATCCCT
GGGTACTCAGACCTACATTTGCAACGTGAACCACAAACCTTCCAACACCAAGGTCG
ACAAGAAAGTGGAGCCTAAGAGCTGCGACAAGACCCACACCTGTCCCCCGTGTCCC
GCCCCTGAGCTGCTGGGCGGCCCCAGCGTGTTCCTCTTCCCGCCTAAGCCGAAGGAC
ACTCTGATGATCTCGAGAACCCCTGAAGTGACCTGTGTGGTGGTGGATGTGTCCCAC
GAGGATCCGGAAGTGAAGTTCAATTGGTACGTGGACGGAGTGGAAGTCCATAACGC
CAAGACCAAGCCCCGCGAGGAACAGTACAACTCAACTTACCGGGTGGTGTCAGTGC
TGACCGTGCTGCACCAAGATTGGCTGAACGGGAAGGAGTACAAGTGCAAAGTCTCC
AACAAGGCGCTGCCGGCCCCCATTGAAAAGACCATCAGCAAGGCTAAGGGCCAGCC
CCGGGAACCACAGGTCTACACCTTGCCCCCTTCCCGGGAGGAAATGACCAAGAACC
AAGTGTCGCTGACGTGCCTGGTCAAGGGCTTTTATCCATCTGACATCGCCGTGGAGT
GGGAAAGCAACGGCCAGCCGGAAAACAACTACAAGACTACCCCGCCTGTGCTGGAC
TCCGACGGCTCGTTCTTCCTGTATTCCAAGCTCACCGTGGATAAGTCCAGATGGCAG
CAGGGCAATGTGTTCAGCTGCAGCGTGATGCATGAGGCCCTGCACAACCACTACAC
TCAGAAATCACTGTCCCTTTCCCCCGGAAAGTAA

[0528] SEQ ID NO:106; a nucleic acid sequence encoding an exemplary kappa light chain constant region

CGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAA
TCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAA
GTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCAC
AGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCA
AAGCAGACTACGAGAAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTG
AGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGTTAA

WHAT IS CLAIMED IS:

1. An antibody specifically binding to human tau, comprising a mature heavy chain variable region comprising CDRs H1, H2 and H3 comprising SEQ ID NOS:8, 9, and 10, respectively except that position H28 can be occupied by N or T, H54 can be occupied by N or D, H56 can be occupied by D or E, and position H58 occupied by V or I, and a mature light chain variable region comprising CDRs L1, L2 and L3 comprising SEQ ID NOS:12, 13, and 14 respectively, except that position L24 can be occupied by K or R, wherein at least one of the following positions is occupied by the amino acid as specified: H1 is occupied by Q, H5 is occupied by Q, H11 is occupied by L, H20 is occupied by L, H23 is occupied by T, H38 is occupied by K, H75 is occupied by S, H56 is occupied by E, H58 is occupied by I, L10 is occupied by T, L17 is occupied by E, L24 is occupied by R, L37 is occupied by Q, L83 is occupied by L, L86 is occupied by H, L100 is occupied by A or Q, L106 is occupied by L.

2. The antibody of claim 1, wherein CDR-H1 comprises SEQ ID NO:8 or SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:9, SEQ ID NO:87, SEQ ID NO:88, or SEQ ID NO:92, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14.

3. The antibody of claim 1, wherein CDR-H1 comprises SEQ ID NO:8 or SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:9, SEQ ID NO:87, or SEQ ID NO:88, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14.

4. The antibody of claim 1, wherein CDR-H1 comprises SEQ ID NO:86, CDR-H2 comprises SEQ ID NO:92, CDR-H3 comprises SEQ ID NO:10, CDR-L1 comprises SEQ ID NO:12 or SEQ ID NO:89, CDR-L2 comprises SEQ ID NO:13, and CDR-L3 comprises SEQ ID NO:14.

5. The antibody of claim 1, wherein CDR-H1 has an amino acid sequence comprising SEQ ID NO:86.

6. The antibody of claim 1, wherein CDR-H2 has an amino acid sequence comprising SEQ ID NO:87.

7. The antibody of claim 1, wherein CDR-H2 has an amino acid sequence comprising SEQ ID NO:88.

8. The antibody of claim 1, wherein CDR-H2 has an amino acid sequence comprising SEQ ID NO:92.

9. The antibody of claim 1, wherein CDR-L1 has an amino acid sequence comprising SEQ ID NO:89.

10. The antibody of claim 1, wherein CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:87.

11. The antibody of claim 1, wherein CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:88.

12. The antibody of claim 1, wherein CDR-H1 has an amino acid sequence comprising SEQ ID NO:86 and CDR-H2 has an amino acid sequence comprising SEQ ID NO:92.

13. The antibody of any one of the preceding claims, wherein the antibody is a humanized antibody, veneered antibody, or chimeric antibody.

14. The humanized antibody of any one of claims 1-13 comprising a humanized mature heavy chain variable region having an amino acid sequence at least 95% identical to any one of SEQ ID NOs:76-80 and SEQ ID NOs:90-91 and a humanized mature light chain variable region having an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85.

15. The humanized antibody of any one of claims 1-13 comprising a humanized mature heavy chain variable region having an amino acid sequence at least 95% identical to any one of SEQ ID NOs:76-80 and a humanized mature light chain variable region having an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85.

16. The humanized antibody of any one of claims 1-13 comprising a humanized mature heavy chain variable region having an amino acid sequence at least 95% identical to any one of SEQ ID NOs:90-91 and a humanized mature light chain variable region having an amino acid sequence at least 90% identical to any one of SEQ ID NOs:83-85.

17. The humanized antibody of any one of claims 14-16, wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H93 is occupied by S and H94 is occupied by T.

18. The humanized antibody of claim 17, provided positions H93 and H94 are occupied by S and T, respectively.

19. The humanized antibody of claim 17, wherein position H91 in the VH region is occupied by F.

20. The humanized antibody of claim 17, wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by E, H5 is occupied by V, H11 is occupied by V, H20 is occupied I, H23 is occupied by K, H38 is occupied by R, H42 is occupied by G, H43 is occupied by K, H66 is occupied by R, H75 is occupied by T, H76 is occupied by D, H81 is occupied by E, H108 is occupied by L, H109 is occupied by V.

21. The humanized antibody of claim 20, provided positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, L, and V, respectively.

22. The humanized antibody of claim 20, wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H17 is occupied by T, H80 is occupied by M, H83 is occupied by R.

23. The humanized antibody of claim 22, provided positions H17, H80, and H83 in the VH region are occupied by T, M, and R, respectively.

24. The humanized antibody of claim 22, wherein position H58 in the VH region is occupied by I.

25. The humanized antibody of claim 24, wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H28 is occupied by T, H67 is occupied by V.

26. The humanized antibody of claim 25, provided positions H28 and H67 in the VH region are occupied by T and V, respectively.

27. The humanized antibody of claim 22, wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H54 is occupied by D, H56 is occupied by E.

28. The humanized antibody of claim 27, provided positions H54 and H56 in the VH region are occupied by D and E, respectively.

29. The humanized antibody of any one of claims 14-16 wherein at least one of the following positions in the VH region is occupied by the amino acid as specified: H1 is occupied by Q or E, H5 is occupied by Q or V, H11 is occupied by L or V , H17 is occupied by S or T, H20 is occupied by L or I, H23 is occupied by T or K, H28 is occupied by N or T, H38 is occupied by K or R, H42 is occupied by E or G, H43 is occupied by Q or K, H54 is occupied by N or D, H56 is occupied by D or E, H58 is occupied by V or I, H66 is occupied by K or R, H67 is occupied by A or V, H75 is occupied by S or T, H76 is occupied by N or D, H80 is occupied by L or M, H81 is occupied by Q or E, H83 is occupied by T or R , H91 is occupied by F or Y, H93 is occupied by S, H94 is occupied by T, H108 is occupied by T or L, H109 is occupied by L or V.

30. The humanized antibody of claim 29, provided positions H91, H93, and H94 in the VH region are occupied by F, S, and T, respectively.

31. The humanized antibody of claim 29, provided positions H1, H5, H11, H20, H23, H38, H42, H43, H66, H75, H76, H81, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, I, K, R, G, K, R, T, D, E, F, S, T,L, and V, respectively.

32. The humanized antibody of claim 29, provided positions H1, H5, H11, H17, H20, H23, H38, H42, H43, H58, H66, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T,I, K, R, G, K, I, R, T, D, M, E, R, S, T, L, and V, respectively.

33. The humanized antibody of claim 29, provided positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, I, R, V, T, D, M, E, R, S, T, L, and V, respectively.

34. The humanized antibody of claim 29, provided positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H58, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, I, R, V, T, D, M, E, R, S, T, L, and V, respectively.

35. The humanized antibody of claim 29, provided positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H91, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, F, S, T, L, and V, respectively.

36. The humanized antibody of claim 29, provided positions H1, H5, H11, H17, H20, H23, H28, H38, H42, H43, H54, H56, H66, H67, H75, H76, H80, H81, H83, H93, H94, H108, and H109 in the VH region are occupied by E, V, V, T, I, K, T, R, G, K, D, E, R, V, T, D, M, E, R, S, T, L, and V, respectively.

37. The humanized antibody of any one of claims 14-16, wherein at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is occupied by S, L10 is occupied by S, L15 is occupied by L, L83 is occupied by V, L86 is occupied by Y, and L106 is occupied by I.

38. The humanized antibody of claim 37, provided positions L7, L10, L15, L83, L86, and L106 are occupied by S, S, L, V, Y, and Y, respectively.

39. The humanized antibody of any one of claims 14-16, wherein at least one of the following positions in the VL region is occupied by the amino acid as specified: L7 is T or S, L10 is T or S, L15 is I or L, L17 is Q or E, L24 is K or R, L37 is L or Q, L45 is K or R, L83 is L or V, L86 is H or Y, L100 is A or Q, L106 is L or I.

40. The humanized antibody of claim 39, provided positions L7, L10, L15, L83, L86, and L106 in the VL region are occupied by S, S, L, V, Y, and I, respectively.

41. The humanized antibody of claim 39, provided positions L7, L10, L15, L17, L24, L37, L45, L83, L86, L100, and L106 in the VL region are occupied by S, S, L, E, R, Q, R, V, Y, Q, and I, respectively.

42. The humanized antibody of claim 14 wherein the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:76-80 and SEQ ID NOs:90-91 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85.

43. The humanized antibody of claim 15 wherein the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:76-80 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85.

44. The humanized antibody of claim 16 wherein the mature heavy chain variable region has an amino acid sequence of any one of SEQ ID NOs:90-91 and the mature light chain variable region has an amino acid sequence of any one of SEQ ID NO:83-85.

45. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

46. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

47. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:76 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

48. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

49. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

50. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:77 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

51. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

52. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

53. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:78 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

54. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

55. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

56. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:79 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

57. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

58. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

59. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:80 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

60. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

61. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

62. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:90 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

63. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:83.

64. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:84.

65. The humanized antibody of claim 42, wherein the mature heavy chain variable region has an amino acid sequence of SEQ ID NO:91 and the mature light chain variable region has an amino acid sequence of SEQ ID NO:85.

66. The antibody of any one of claims 1-13, wherein the antibody is a chimeric antibody.

67. The antibody of any one of claims 1-13, wherein the antibody is a veneered antibody.

68. The antibody of any one of claims 1-67 that is an intact antibody.

69. The antibody of any one of claims 1-67 that is a binding fragment.

70. The antibody of claim 69, wherein the binding fragment is a single-chain antibody, Fab, or Fab'2 fragment.

71. The antibody of any one of claims 1-67 that is a Fab fragment, or single chain Fv.

72. The antibody of any one of the preceding claims, wherein the isotype is human IgG1.

73. The humanized antibody of any one of claims 13-65 and 67-72, wherein the mature light chain variable region is fused to a light chain constant region and the mature heavy chain variable region is fused to a heavy chain constant region.

74. The humanized antibody of claim 73, wherein the heavy chain constant region is a mutant form of a natural human heavy chain constant region which has reduced binding to a Fcγ receptor relative to the natural human heavy chain constant region.

75. The humanized antibody of claim 73 or claim 74, wherein the heavy chain constant region is of IgG1 isotype.

76. The humanized antibody of claim 75, wherein the mature heavy chain variable region is fused to a heavy chain constant region having the sequence of SEQ ID NO:103 with or without the C-terminal lysine and/or the mature light chain variable region is fused to a light chain constant region having the sequence of SEQ ID NO:104.

77. The antibody of claim 73 having at least one mutation in the constant region.

78. The antibody of claim 77, wherein the mutation reduces complement fixation or activation by the constant region.

79. The antibody of claim 78 having a mutation at one or more of positions 241, 264, 265, 270, 296, 297, 318, 320, 322, 329 and 331 by EU numbering.

80. The antibody of claim 79 having alanine at positions 318, 320 and 322.

81. The antibody of any one of claims 1-74 wherein the isotype is of human IgG2 or IgG4 isotype.

82. The antibody of any one of claims 1-81, wherein the antibody is at least 95% w/w pure.

83. The antibody of any preceding claim, wherein the antibody is conjugated to a therapeutic, cytotoxic, cytostatic, neurotrophic, or neuroprotective agent.

84. A pharmaceutical composition comprising an antibody as defined in any of claims 1-83 and a pharmaceutically-acceptable carrier.

85. A nucleic acid encoding the heavy chain and/or light chain of an antibody as described in any one of claims 1-84.

86. The nucleic acid of claim 85 having a sequence comprising any one of SEQ ID NOs:30-31, 93-99, 100-102, and 105-106.

87. The nucleic acid of claim 85 having a sequence comprising any one of SEQ ID NOs:30-31, 93-97, 100-102, and 105-106.

88. The nucleic acid of claim 85 having a sequence comprising any one of SEQ ID NOs:30-31, 98-99, 100-102, and 105-106.

89. A vector comprising a nucleic acid encoding a mature heavy chain variable region and a mature light chain variable region operably linked to one or more regulatory sequences to effect expression in a mammalian cell of an antibody as described in any one of claims 1-83.

90. The vector of claim 89, wherein the nucleic acid further encodes a heavy chain constant region fused to the mature heavy chain variable region and a light chain constant region fused to the mature light chain variable region.

91. The vector of claim 90, wherein the heavy chain constant region has the sequence of SEQ ID NO:103 with or without the C-terminal lysine and the light chain constant region has the sequence of SEQ ID NO:104.

92. The vectors of claim 90, wherein the heavy chain constant region is encoded by the sequence of SEQ ID NO:105 and the light chain constant region is encoded by the sequence of SEQ ID NO:106.

93. The vector of claim 89, wherein the antibody is a scFv.

94. The vector of claim 89, wherein the antibody is a Fab fragment.

95. The vector of claim 89, wherein the one or more regulatory sequences include one or more of a promoter, enhancer, ribosome binding site, and transcription termination signal.

96. The vector of claim 89, wherein the nucleic acid further encodes signal peptides fused to the mature heavy and light chain variable regions.

97. The vector of claim 89, wherein the nucleic acid is codon-optimized for expression in a host cell.

98. The vector of claim 89, wherein the one or more regulatory sequences include a eukaryotic promoter.

99. The vector of claim 89, wherein the nucleic acid further encodes a selectable gene.

100. A recombinant expression vector comprising a nucleic acid of claim 85.

101. A host cell transformed with the recombinant expression vector of claim 100.

102. A host cell comprising the nucleic acid of claim 89.

103. A method of expressing an antibody in a mammalian cell comprising incorporating the nucleic acid according to claim 89 into the genome of a transgenic animal, whereby the antibody is expressed.

104. First and second vectors respectively comprising nucleic acids encoding a mature heavy chain variable region and a mature light chain variable region, each operably linked to one or more regulatory sequences to effect expression in a mammalian cell of an antibody as described in any one of claims 1-83.

105. The vectors of claim 104, wherein the nucleic acids respectively further encode a heavy chain constant region fused to the mature heavy chain variable region and a light chain constant region fused to the mature light chain variable region.

106. The vectors of claim 105, wherein the heavy chain constant region has the sequence of SEQ ID NO:103 with or without the C-terminal lysine and the light chain constant region has the sequence of SEQ ID NO:104.

107. The vectors of claim 105, wherein the heavy chain constant region is encoded by the sequence of SEQ ID NO:105 and the light chain constant region is encoded by the sequence of SEQ ID NO:106.

108. A host cell comprising the nucleic acids of claim 104.

109. A method of expressing an antibody in a mammalian cell comprising incorporating the nucleic acids according to claim 104 into the genome of a transgenic animal, whereby the antibody is expressed.

110. A method of humanizing a mouse antibody, the method comprising:

(a) selecting one or more acceptor antibodies;

(b) identifying the amino acid residues of the mouse antibody to be retained;

(c) synthesizing a nucleic acid encoding a humanized heavy chain comprising CDRs of the mouse antibody heavy chain and a nucleic acid encoding a humanized light chain comprising CDRs of the mouse antibody light chain; and

(d) expressing the nucleic acids in a host cell to produce a humanized antibody;

wherein the mouse antibody is 3D6, wherein 3D6 is characterized by a mature heavy chain variable region of SEQ ID NO:7 and a mature light chain variable region of SEQ ID NO:11.

111. A method of producing a humanized, chimeric, or veneered antibody, the method comprising:

(a) culturing cells transformed with nucleic acids encoding the heavy and light chains of the antibody, so that the cells secrete the antibody; and

(b) purifying the antibody from cell culture media;

wherein the antibody is a humanized, chimeric, or veneered form of 3D6.

112. A method of producing a cell line producing a humanized, chimeric, or veneered antibody, the method comprising:

(a) introducing a vector encoding heavy and light chains of an antibody 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;

wherein the antibody is a humanized, chimeric, or veneered form of 3D6.

113. The method of claim 112 further comprising propagating the cells under selective conditions and screening for cell lines naturally expressing and secreting the antibody in an amount of at least 100 mg/L/10^6 cells/24 h.

114. A method of inhibiting or reducing aggregation of tau in a subject having or at risk of developing a tau-mediated amyloidosis, comprising administering to the subject an effective regime of the antibody of any one of claims 1-84, thereby inhibiting or reducing aggregation of tau in the subject.

115. The method of claim 114, wherein the antibody is a humanized version of 3D6.

116. A method of treating or effecting prophylaxis of a tau-related disease in a subject, comprising administering an effective regime of an antibody as defined by any one of claims 1-84 and thereby treating or effecting prophylaxis of the disease.

117. A method of claim 116 wherein the tau-related disease is Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

118. A method of claim 117 wherein the tau-related disease is Alzheimer's disease.

119. The method of claim 118 wherein the patient is an ApoE4 carrier.

120. A method of reducing aberrant transmission of tau comprising administering an effective regime of an antibody as defined in any of claims 1-84 and thereby reducing transmission of tau.

121. A method of inducing phagocytosis of tau comprising administering an effective regime of an antibody as defined in any of claims 1-84 and thereby inducing phagocytosis of tau.

122. A method of inhibiting tau aggregation or deposition comprising administering an effective regime of an antibody as defined in any of claims 1-84 thereby inhibiting tau aggregation or deposition.

123. A method of inhibiting formation of tau tangles comprising administering an effective regime of an antibody as defined in any of claims 1-84.

124. A method of detecting tau protein deposits in a subject having or at risk of a disease associated with tau aggregation or deposition, comprising administering to a subject an antibody defined by any one of claims 1-84, and detecting the antibody bound to tau in the subject.

125. A method of claim 124, wherein the disease associated with tau aggregation or deposition is Alzheimer's disease, Down's syndrome, mild cognitive impairment, primary age-related tauopathy, postencephalitic parkinsonism, posttraumatic dementia or dementia pugilistica, Pick's disease, type C Niemann-Pick disease, supranuclear palsy, frontotemporal dementia, frontotemporal lobar degeneration, argyrophilic grain disease, globular glial tauopathy, amyotrophic lateral sclerosis/parkinsonism dementia complex of Guam, corticobasal degeneration (CBD), dementia with Lewy bodies, Lewy body variant of Alzheimer disease (LBVAD), chronic traumatic encephalopathy (CTE), globular glial tauopathy (GGT), or progressive supranuclear palsy (PSP).

126. A method of claim 124, wherein the antibody is administered by intravenous injection into the body of the subject.

127. A method of claim 124, wherein the antibody is administered directly to the brain of the subject by intracranial injection or by drilling a hole through the skull of the subject.

128. A method of claim 124, wherein the antibody is labeled.

129. A method of claim 128, wherein the antibody is labeled with a fluorescent label, a paramagnetic label, or a radioactive label.

130. A method of claim 129, wherein the radioactive label is detected using positron emission tomography (PET) or single-photon emission computed tomography (SPECT).

131. A method of measuring efficacy of treatment in a subject being treated for a disease associated with tau aggregation or deposition, comprising

(a) measuring a first level of tau protein deposits in the subject prior to treatment by administering to a subject an antibody defined by any one of claims 1-84, and detecting a first amount of the antibody bound to tau in the subject,

(b) administering the treatment to the subject,

(c) measuring a second level of tau protein deposits in the subject after treatment by administering to a subject the antibody, and detecting the antibody bound to tau in the subject,

wherein a decrease in the level of tau protein deposits indicates a positive response to treatment.

132. A method of measuring efficacy of treatment in a subject being treated for a disease associated with tau aggregation or deposition, comprising

(a) measuring a first level of tau protein deposits in the subject prior to treatment by administering to a subject an antibody defined by any one of claims 1-84, and detecting a first amount of antibody bound to tau in the subject,

(b) administering the treatment to the subject,

(c) measuring a second level of tau protein deposits in the subject after treatment by administering to a subject the antibody, and detecting a second amount of antibody bound to tau in the subject,

wherein no change in the level of tau protein deposits or a small increase in tau protein deposits indicates a positive response to treatment.