(54) Title: ANTIBODY-BASED MOLECULES SPECIFIC FOR THE TRUNCATED ASP421 EPITOPE OF TAU AND THEIR USES IN THE DIAGNOSIS AND TREATMENT OF TAUOPATHY
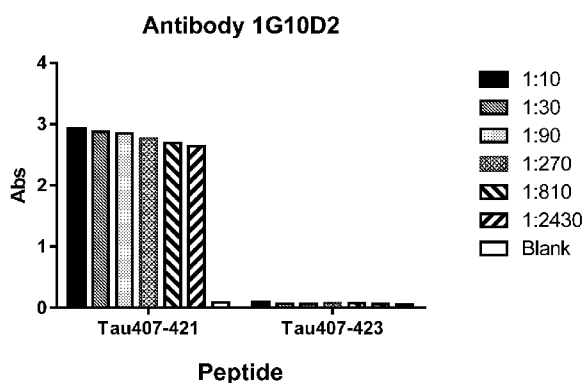
Figure 1A

(57) Abstract: The present invention relates to antibody-based molecules (including single domain antibody fragment, scFv molecules, antibodies, antibody fragments, diabodies, and the epitope-binding domains thereof) that are capable of immunospecifically and selectively binding to the truncated Asp421 epitope of Tau. Such antibody-based molecules are useful to detect pathological Tau protein conformer if present in a biological sample, especially in conjunction with the diagnosis and/or treatment of Alzheimer's disease or other tauopathy, and thus provide a diagnostic for Alzheimer's disease and other Tau pathologies. The antibody-based molecules of the present invention have particular utility as diagnostic markers for, Alzheimer's disease and related tauopathies and as pharmaceutical compositions for the treatment of such conditions.

Title Of The Invention:

Antibody-Based Molecules Specific for the Truncated Asp421 Epitope of Tau and Their Uses in the Diagnosis and Treatment of Tauopathy

Cross-Reference To Related Applications

[0001] This Application claims priority to U.S. Provisional Patent Applns. Serial No. 62/204,699 (filed on August 13, 2015; pending), and 62/211,123 (filed on August 28, 2015; pending), each of which application is hereby incorporated by reference herein in its entirety.

Statement Regarding Federally Sponsored Research Or Development

[0002] This invention was made with government support under Grant Nos. NS077239, AG032611 and AG020197 awarded by the National Institutes of Health (NIH). The government has certain rights in the invention.

Reference To Sequence Listing

[0003] This application includes one or more Sequence Listings pursuant to 37 C.F.R. 1.821 et seq., which are disclosed in computer-readable media (file name: 1400-0008PCT_ST25.txt, created on August 11, 2016, and having a size of 170,987 bytes), which file is herein incorporated by reference in its entirety.

Field Of The Invention

[0004] The present invention relates to antibody-based molecules (including single domain antibody fragment, scFv molecules, antibodies, antibody fragments, diabodies, and the epitope-binding domains thereof) that are capable of immunospecifically and selectively binding to the truncated Asp421 epitope of Tau. Such antibody-based molecules are useful to detect pathological Tau protein conformer if present in a biological sample, especially in conjunction with the diagnosis and/or treatment of Alzheimer's disease or other tauopathy, and thus provide a diagnostic for Alzheimer's disease and other Tau pathologies. The antibody-based molecules of the present invention have particular utility as diagnostic markers for, Alzheimer's disease and related tauopathies and as pharmaceutical compositions for the treatment of such conditions.

Background Of The Invention

[0005] Alzheimer's disease is the most common form of dementia affecting more than 20 million people worldwide. Diagnosis of the disease, in particular at an early point, is troublesome and difficult and there exists a need for accurate diagnosis of tauopathies such as Alzheimer's disease. Antibody detection of abnormal Tau in cerebrospinal fluid has shown some promise (Blennow, K. *et al.* "*Cerebrospinal Fluid And Plasma Biomarkers In Alzheimer Disease,*" Nat. Rev. Neurol. 6, 131-144 (2010) and Weiner *et al.* "*The Alzheimer's Disease Neuroimaging Initiative: A Review Of Papers Published Since Its Inception,*" Alzheimers. Dement. 9, e111-e194 (2013)).

[0006] Over the years, antibody detection of phospho-Tau protein in cerebrospinal fluid has shown some utility for diagnosis of Alzheimer's disease (Blennow, K. *et al.* "*Cerebrospinal Fluid And Plasma Biomarkers In Alzheimer Disease,*" Nat. Rev. Neurol. 6, 131-144 (2010); Lewis, J. *et al.* "*Neurofibrillary Tangles, Amyotrophy And Progressive Motor Disturbance In Mice Expressing Mutant (P301L) Tau Protein,*" Nat. Genet. 25, 402-405; Weiner, M.W. *et al.* (2013) "*The Alzheimer's Disease Neuroimaging Initiative: A Review Of Papers Published Since Its Inception,*" Alzheimers. Dement. 9: e111-e194), suggesting that further development in this arena is warranted (see, Congdon, E.E. (2014) "*Harnessing The Immune System For Treatment And Detection Of Tau Pathology,*" J. Alzheimers. Dis. 40:S113-S121). However, CSF Tau levels in other tauopathies are usually not altered compared to controls (Theunis, C. *et al.* "*Efficacy And Safety Of A Liposome-Based Vaccine Against Protein Tau, Assessed In Tau.P301L Mice That Model Tauopathy,*" PLoS. One. 8, e72301 (2013); Hales, C.M. *et al.* (2013) "*From Frontotemporal Lobar Degeneration Pathology To Frontotemporal Lobar Degeneration Biomarkers,*" Int. Rev. Psychiatry 25:210-220), and imaging dyes may not detect pathological Tau in all tauopathies (Fodero-Tavoletti, M. T. *et al.* (2014) "*Assessing THK523 Selectivity For Tau Deposits In Alzheimer's Disease And Non-Alzheimer's Disease Tauopathies,*" Alzheimers. Res. Ther. 6:11). Imaging these Tau lesions in concert with amyloid-β (Aβ) is more likely to lead to accurate diagnosis as the regional pattern of Tau aggregates differs between the different tauopathies. Furthermore, all of them except Alzheimer's disease are in part defined by lack of Aβ deposition. *In vivo* imaging of Aβ plaques using compounds that bind well to β-sheets is already in clinical use (Mason, N.S. *et al.* (2013) "*Positron Emission Tomography Radioligands For In Vivo Imaging Of ABeta Plaques,*" J. Labelled Comp. Radiopharm. 56:89-95). Several such dye-based Tau-binding ligands have been identified recently in

preclinical studies and some of those are being evaluated (Fodero-Tavoletti, M. T. *et al.* (2014) *"Assessing THK523 Selectivity For Tau Deposits In Alzheimer's Disease And Non-Alzheimer's Disease Tauopathies,"* Alzheimers. Res. Ther. 6:11; Fodero-Tavoletti, M. T. *et al.* (2011) *"18F-THK523: A Novel In Vivo Tau Imaging Ligand For Alzheimer's Disease,"* Brain 134:1089-1100; Zhang, W. *et al.* (2012) *"A Highly Selective And Specific PET Tracer For Imaging Of Tau Pathologies,"* J. Alzheimers. Dis. 31:601-612; Chien, D.T. *et al.* (2013) *"Early Clinical PET Imaging Results With The Novel PHF-Tau Radioligand [F-18]-T807,"* J. Alzheimers. Dis. 34:457-468; Maruyama, M.H. *et al.* (2013) *"Imaging Of Tau Pathology In A Tauopathy Mouse Model And In Alzheimer Patients Compared To Normal Controls,"* Neuron 79:1094-1108; Okamura, N. *et al.* (2005) *"Quinoline And Benzimidazole Derivatives: Candidate Probes For In Vivo Imaging Of Tau Pathology In Alzheimer's Disease,"* J. Neurosci. 25:10857-10862; Harada, R., *et al.* (2013) *"Comparison Of The Binding Characteristics Of [18F]THK-523 And Other Amyloid Imaging Tracers To Alzheimer's Disease Pathology,"* Eur. J. Nucl. Med. Mol. Imaging 40:125-132; Ono, M. *et al.* (2011) *"Rhodanine And Thiohydantoin Derivatives For Detecting Tau Pathology In Alzheimer's Brains,"* ACS Chem. Neurosci. 2:269-275; Xia, C.F. *et al.* (2013) *"[(18)F]T807, A Novel Tau Positron Emission Tomography Imaging Agent For Alzheimer's Disease,"* Alzheimers. Dement. 9:666-676; Chien, D.T. (2014) *"Early Clinical PET Imaging Results With The Novel PHF-Tau Radioligand [F18]-T808,"* J. Alzheimers. Dis. 38:171-184; Villemagne, V.L. *et al.* (2014) *"In Vivo Evaluation Of A Novel Tau Imaging Tracer For Alzheimer's Disease,"* Eur. J. Nucl. Med. Mol. Imaging 41:816-826; Okamura, N. *et al.* (2014) *"Non-Invasive Assessment Of Alzheimer's Disease Neurofibrillary Pathology Using 18F-THK5105 PET,"* Brain 137:1762-1771). The hope and promise for Tau based ligands is that they will be better than Aβ ligands to monitor the status and progression of neurodegeneration. Antibody-based probes are likely to provide greater specificity for detecting Tau lesions. In particular, smaller antibody fragments that bind to Tau are attractive as ligands for *in vivo* imaging to detect Tau lesions in patients with Alzheimer's disease or other tauopathies.

[0007]   Within the cancer field, therapeutic antibodies have routinely been co-developed as imaging agents, and several such antibodies and Fab molecules are FDA approved for tumor imaging (Kaur, S. *et al. "Recent Trends In Antibody-Based Oncologic Imaging,"* Cancer Lett. 315, 97-111 (2012)).

[0008]   The present inventors have found antibody-derived molecules that provide excellent specificity for detecting Tau lesions, and in particular smaller single-chain variable antibody fragments (scFv molecules) which are attractive for *in vivo* imaging of Tau aggregates. It is envisaged that these antibody-derived imaging ligands can be useful in monitoring disease progression of Tau pathology, the efficacy of Tau-targeting therapies, and to identify Aβ negative tauopathies. Additionally, such antibody-derived molecules have utility as therapeutics in the prevention, treatment and management of Alzheimer's disease and other tauopathies.

Summary Of The Invention

[0009]   The present invention relates to antibody-based molecules (including single domain antibody fragment, scFv molecules, antibodies, antibody fragments, diabodies, and the epitope-binding domains thereof) that are capable of immunospecifically and selectively binding to the truncated Asp421 epitope of Tau. Such antibody-based molecules are useful to detect pathological Tau protein conformer if present in a biological sample, especially in conjunction with the diagnosis and/or treatment of Alzheimer's disease or other tauopathy, and thus provide a diagnostic for Alzheimer's disease and other Tau pathologies. The antibody-based molecules of the present invention have particular utility as diagnostic markers for, Alzheimer's disease and related tauopathies and as pharmaceutical compositions for the treatment of such conditions.

[0010]   In detail, the invention concerns a binding molecule that is capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, wherein the epitope is present on a peptide having the sequence of Tau 407-421 (**SEQ ID NO:7**): HLSNVSSTGSIDMVD.

[0011]   The invention particularly concerns the embodiment of such binding molecule wherein the molecule competes for binding with an antibody selected from the group consisting of: Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3 / 5G2G6.

[0012]   The invention particularly concerns the embodiment of such binding molecule wherein the molecule comprises:

(a)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:9, 10 and 11**; and

       (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:13, 14** and **15**;

(b)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:17, 18** and **19**; and

       (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:21, 22** and **23**;

(c)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:25, 26** and **27**; and

       (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:33, 34** and **35**;

(d)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:29, 30** and **31**; and

       (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:33, 34** and **35**;

or

(e)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:37, 38** and **39**; and

       (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:41, 42** and **43**.

[0013]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule comprises:

(a)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:97, 98** and **99**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:100, 101** and **102**.

[0014]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein upon peripheral injection into a recipient, the molecule substantially co-localizes with a Tau aggregate.

[0015]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule is an antibody, a diabody, an scFv, or comprises an epitope-binding fragment of an antibody, diabody or scFv.

[0016]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule is an antibody.

[0017]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule is a humanized antibody or comprises an epitope-binding fragment of a humanized antibody.

[0018]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule is an scFv.

[0019]   The invention particularly concerns the embodiment of any of the above-described binding molecules wherein the molecule is detectably labeled, and especially wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label.

[0020]   The invention additionally concerns the use of any of such antibody-based molecules for detecting or measuring the presence or amount of the truncated Tau protein in the brain, cerebrospinal fluid, blood, serum or plasma of a recipient subject.

[0021]   The invention particularly concerns the embodiment of such use, wherein the detection or measurement comprises *in vivo* or *ex vivo* imaging of the antibody-based molecule bound to the truncated Tau protein.

[0022]   The invention particularly concerns the embodiments of such uses wherein the detection or measurement is for diagnosing Alzheimer's disease or another tauopathy of a subject.

[0023]   The invention additionally concerns an *in vivo* medicament for the treatment of Alzheimer's disease or another tauopathy of a subject, wherein the medicament comprises any of the above-described antibody-based molecules in an amount effective to treat the Alzheimer's disease or other tauopathy, and one or more carriers, diluents and/or stabilizers.

[0024]   The invention additionally concerns the use of such *in vivo* medicament for the treatment of Alzheimer's disease or another tauopathy of the subject.

[0025]   The invention particularly concerns the embodiments of such uses wherein the subject is a human.

[0026]   The invention additionally concerns a kit for detecting or measuring the presence or amount of the truncated Tau protein in the brain of a subject, or for diagnosing Alzheimer's disease or another tauopathy in a subject, wherein the kit comprises an above-described antibody-based molecule.

[0027]   The invention particularly concerns the embodiments of any of such uses, medicaments or kits wherein the tauopathy is selected from the group comprising frontotemporal dementia, parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy, corticobasal degeneration, Pick's disease, progressive subcortical gliosis, tangle only dementia, diffuse neurofibrillary tangles with calcification, argyrophilic grain dementia, amyotrophic lateral sclerosis parkinsonism-dementia complex, dementia pugilistica, Down syndrome, Gerstmann-Straussler-Scheinker disease, Hallerworden-Spatz disease, inclusion body myositis, Creutzfeld- Jakob disease, multiple system atropy, Niemann-Pick disease type C, prion protein cerebral amyloid angiopathy, subacute sclerosing panencephalitis, myotonic dystrophy, non-guanamian motor neuron disease with neurofibrillary tangles, postencephalitic parkinsonism, acute traumatic brain injury and chronic traumatic encephalopathy.

Brief Description Of The Drawings

[0028]   **Figures 1A-1E** show the immunospecificity of Antibodies 1G10D2 (**Figure 1A**), Antibody 1G11A10 (**Figure 1B**), Antibody 5B3C11 (**Figure 1C**), Antibody 5G2A3 (**Figure 1D**) and Antibody 5G2G6 (**Figure 1E**) for the Truncated Asp421 Epitope of Tau at dilutions of hybridoma culture supernatants of 1:10, 1:30, 1:90, 1:270, 1:810 and 1:2430.

[0029]   **Figures 2A-2B** show the immunospecificity of Antibodies 1G11A10 (**Figure 2A**) and 5G2A3 (**Figure 2C**) for the Truncated Asp421 Epitope of Tau at antibody dilutions of 1:1000, 1:3000, 1:9000, 1:27000 and 1:81000.

[0030]   **Figures 3A-3B** show the effect of Antibody 5G2A3 and Antibody 1G11A10 (10 μg/mL), over time, on phosphorylated Tau levels of mixed cortical (**Figure 3A**) or pure neuronal (**Figure 3B**) cultures of JNPL3 mice that were pre-treated with PHF (1 μg/mL). Antibody 5G2G6 was also tested in the pure neuronal culture. The results presented in **Figure 3A** are obtained from Western blot analysis using detection antibody PHF-1 (**Table 6**). The PHF-treated mixed cultures that were incubated with IgG (10 μg/mL) were considered as control for this set of experiment. The results presented in **Figure 3B** are

obtained from Western blot analysis using detection antibody specific for $^{\{P\}}$Ser199 Tau, with IgG-treated controls set at 100%. The data is not normalized.

[0031]   **Figures 4A-4B** show the effect of Antibody 5G2A3 and Antibody 1G11A10 (10 µg/mL), over time, on intracellular Tau using mixed cortical (**Figure 4A**) or pure neuronal (**Figure 4B**) cultures of JNPL3 mice that were pre-treated with PHF (1 µg/mL). Antibody 5G2G6 was also tested in the pure neuronal culture. The results presented in **Figure 4A** (**Table 7**) and **Figure 4B** are obtained from Western blot analysis using anti-human Tau antibody (Dako). The PHF-treated cultures that were incubated with IgG (10 µg/mL) were considered as control for both sets of experiments and are presented in **Figures 3A-3B**. The data is not normalized.

[0032]   **Figures 5A-5B** show that Antibody 5G2A3 proved to be more effective than Antibody 1G11A10 in reducing the phospho-Tau levels in mixed cortical (**Figure 5A**) and primary neuronal (**Figure 5B**) culture. **Figure 5A**: The mixed cortical cultures treated with Antibody 5G2A3 (10µg/ml) for 48h, 72h and 96h demonstrated very significant decrease in the phospho-Tau levels against Ser199 epitope i.e. 66%, 81% and 94% with p<0.0001 respectively when compared to the control cells, whereas the cells treated with Antibody 1G11A10 (10µg/ml) were unable to significantly decrease the phospho-Tau levels. The PHF treated mixed cortical cultures incubated with IgG (10µg/ml) were considered as control for this set of experiment. **Figure 5B**: Antibody 5G2A3 proved very effective in reducing phospho-Tau levels in primary neurons at Ser199 epitope by demonstrating 90%, 89%, 76% and 68% reduction for 24h, 48h, 72h and 96h respectively, with p<0.0001. Antibody 1G11A10 treatment at 10µg/ml also demonstrated 68%, 67% and 68% reduction in phospho-Tau levels from 24h up to 72h, p< 0.05, which subsided at 96h showing only 9% reduction.

[0033]   **Figures 6A-6B** show that Antibody 5G2A3 proved to be effective in reducing total Tau in mixed cortical and primary neuronal culture whereas Antibody 1G11A10 was more effective in reducing total Tau levels in primary neuronal culture. **Figure 6A**: Antibody 5G2A3 treatment using mixed cortical culture was able to reduce the total Tau levels i.e. up to 54% until 96h, p<0.05, whereas Antibody 1G11A10 treatment demonstrated significant reduction in total Tau levels only at 24h (41%) and 96h (36%), p<0.0001 when compared to the control cells that were treated with IgG (10µg/ml). **Figure 6A**: Antibody 5G2A3 treatment in primary neurons proved effective in significantly reducing total Tau levels at 24h (58%), 48h (45%) and 96h (43%) with p<0.05 when compared with the control, whereas

Antibody 1G11A10 demonstrated significant reduction in the levels of total Tau only at 48h showing 65% reduction, p<0.05 in primary neuronal culture.

[0034]   **Figure 7** shows that Antibody 5G2A3 treatment increased NeuN levels in the mixed cortical cultures. Mixed cortical cultures from day 0 JNPL3 mice were pretreated with PHF (1μg/ml) followed by Antibody 5G2A3 (10μg/ml) and Antibody 1G11A10 (10μg/ml) treatment for further 24h, 48h, 72h or 96h. A western blot analysis undertaken against NeuN, which is a neuronal nuclei marker, demonstrated a significant increase in the levels of NeuN for 72h (114%) and 96h (170%) compared to the IgG (10μg/ml) treated control cells. Antibody 1G11A10 treatment did not show any significant alteration in the levels of NeuN.

[0035]   **Figure 8** shows that Iba1 expression was reduced after Antibody 5G2A3 treatment in mixed cortical culture. The mixed cortical cells from day 0 JNPL3 mice were pretreated with PHF (1μg/ml) followed by treatment with Antibody 5G2A3 or Antibody 1G11A10 (10μg/ml each) for 24h, 48h, 72h or 96h, respectively. Immunoblots undertaken against Iba1 antibody, a microglia specific marker, demonstrated a significant decrease in the levels of Iba1 at 72h (38%, p<0.05) and 96h (73%, p=0.0004), when compared to control for the respective time points, whereas Antibody 1G11A10 treatment was unable to demonstrate any significant difference in the Iba1 expression for any time points. The cells treated with IgG (10μg/ml) were considered as control for both the mixed cortical and primary neuronal cultures.

[0036]   **Figure 9** shows the effect on NeuN levels of co-incubation of high dose PHF (10 μg/ml) with antibodies that are immunospecific for the Truncated Asp421 Epitope of Tau (10 μg/ml) in mixed cortical cultures, as measured by changes in NeuN levels. Under these more toxic conditions (higher PHF dose), a similar pattern is observed as in **Example 3** with Antibody 5G2A3 being very effective in clearing pathological tau and preventing its toxicity, whereas the lower affinity Antibody 1G11A10 is less effective.

[0037]   **Figure 10** shows the effect on phosphorylated Tau levels, normalized to NeuN levels, seen upon co-incubation of high dose PHF (10 μg/ml) with antibodies that are immunospecific for the Truncated Asp421 Epitope of Tau (10 μg/ml) in mixed cortical cultures, as measured by changes in binding to the Ser199 epitope, normalized to NeuN levels. The co-incubation of Antibody 5G2A3 antibody with PHF demonstrated a significant decrease in the level of phospho-Tau compared to the cells treated with PHF alone and PHF

+ IgG, whereas co-incubation of Antibody 1G11A10 antibody with PHF was unable to demonstrate any such alteration in the levels of phospho-Tau.

[0038]   **Figure 11** shows the effect on total Tau (both phosphorylated as well as non-phosphorylated tau), normalized to NeuN levels, seen upon co-incubating a high dose of PHF (10μg/ml) with antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau.

[0039]   **Figure 12** shows the effect on Iba1 levels seen upon co-incubating a high dose of PHF (10μg/ml) with antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau.

[0040]   **Figures 13A-13B** show the tissue reactivity of antibodies that are immunospecific for the Truncated Asp421 Epitope of Tau in JNPL3 tauopathy mice (**Figure 13A**) and hTau tauopathy mice (**Figure 13B**). Low speed supernatant (LSS) samples from such mice were evaluated. The ordinate values of the Figures are the codenames of the specific mice being analyzed. White bars, Antibody 5G2A3; gray bars, Antibody 1G11A10; black bars, anti-Tau antibody C3.

[0041]   **Figure 14** shows the tissue reactivity of antibodies that are immunospecific for the Truncated Asp421 Epitope of Tau in brain supernatant samples from human (control) brain and purified PHF from human AD brain. The ordinate values of the Figure are the codenames of the specific subject being analyzed. White bars, Antibody 5G2A3; gray bars, Antibody 1G11A10; black bars, anti-Tau antibody C3.

Detailed Description Of The Invention

[0042]   The present invention relates to antibody-based molecules (including single domain antibody fragment, scFv molecules, antibodies, antibody fragments, diabodies, and the epitope-binding domains thereof) that are capable of immunospecifically and selectively binding to the truncated Asp421 epitope of Tau. Such antibody-based molecules are useful to detect pathological Tau protein conformer if present in a biological sample, especially in conjunction with the diagnosis and/or treatment of Alzheimer's disease or other tauopathy, and thus provide a diagnostic for Alzheimer's disease and other Tau pathologies. The antibody-based molecules of the present invention have particular utility as diagnostic

markers for, tauopathy (and in particular for Alzheimer's disease and related tauopathies) and as pharmaceutical compositions for the treatment of such conditions.

[0043]   The term "**tauopathy**," as used herein, encompasses any neurodegenerative disease that involves the pathological aggregation of the microtubule protein Tau within the brain. Accordingly, in addition to both familial and sporadic Alzheimer's disease, the tauopathies of the present invention include, without limitation, frontotemporal dementia, parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy, corticobasal degeneration, Pick's disease, progressive subcortical gliosis, tangle only dementia, diffuse neurofibrillary tangles with calcification, argyrophilic grain dementia, amyotrophic lateral sclerosis parkinsonism-dementia complex, dementia pugilistica, Down syndrome, Gerstmann-Straussler-Scheinker disease, Hallerworden-Spatz disease, inclusion body myositis, Creutzfeld-Jakob disease, multiple system atropy, Niemann-Pick disease type C, prion protein cerebral amyloid angiopathy, subacute sclerosing panencephalitis, myotonic dystrophy, non-guanamian motor neuron disease with neurofibrillary tangles, postencephalitic parkinsonism, acute traumatic brain injury and chronic traumatic encephalopathy.

[0044]   The antibody-based molecules of the present invention provide greater specificity than β-sheet dyes for detecting Tau lesions in patients with AD or other tauopathies. In particular, smaller antibody fragments that bind to Tau are attractive as ligands for *in vivo* imaging. Their smaller size compared to antibodies leads to better access to Tau aggregates. Another advantage is their relatively rapid clearance from the circulation compared to unmodified antibodies that have longer half-lives. Within the cancer field, therapeutic antibodies have routinely been co-developed as imaging agents, and several such antibodies and Fab's or smaller diabodies and scFv molecules with better pharmacokinetic properties approved or proposed as tumor imaging agents (see, Kaur, S. *et al.* (2012) *"Recent Trends In Antibody-Based Oncologic Imaging,"* Cancer Lett. 315:97-111; Olafsen, T. *et al.* (2010) *"Antibody Vectors For Imaging,"* Semin. Nucl. Med. 40:167-181).

I.   **Tau and the Preferred Immunogenic Tau Peptides of the Present Invention**

[0045]   As used herein, the term "**Tau**" is synonymous with the Tau protein and refers to any of the Tau protein isoforms (identified in for example UniProt as P10636, 1-9). Tau is a soluble microtubule-associated protein that is dynamically phosphorylated and dephosphorylated by a host of kinase enzymes during the cell cycle. Tau's ability to stabilize

microtubules is dependent on the extent of its phosphorylation. In its dephosphorylated form, the protein is able to interact with tubulin to stabilize microtubules and promote tubulin assembly into microtubules (which form the cytoskeleton of the cell and are the major constituents of the mitotic spindles that pull apart eukaryotic chromosomes in mitosis). In its phosphorylated form, Tau is able to dissociate from microtubules, thereby permitting mitosis to occur. The phosphorylation of Tau acts thus as a direct microtubule association-dissociation switch within the neuron (Pedersen, J.T. *et al.* (2015) "*Tau Immunotherapy For Alzheimer's Disease,*" Trends Mol. Med. 2015 Apr 3. pii: S1471-4914(15)00058-1; pages 1-9, hereby incorporated by reference herein in its entirety).

[0046]   The amino acid numbering of Tau residues provided herein is given with respect to **SEQ ID NO:1**, as shown below, with methionine being the first amino acid residue thereof.

SEQ ID NO:1:

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MAEPRQEFEV  MEDHAGTYGL  GDRKDQGGYT  MHQDQEGDTD  AGLKESPLQT
PTEDGSEEPG  SETSDAKSTP  TAEDVTAPLV  DEGAPGKQAA  AQPHTEIPEG
TTAEEAGIGD  TPSLEDEAAG  HVTQARMVSK  SKDGTGSDDK  KAKGADGKTK
IATPRGAAPP  GQKGQANATR  IPAKTPPAPK  TPPSSGEPPK  SGDRSGYSSP
GSPGTPGSRS  RTPSLPTPPT  REPKKVAVVR  TPPKSPSSAK  SRLQTAPVPM
PDLKNVKSKI  GSTENLKHQP  GGGKVQIINK  KLDLSNVQSK  CGSKDNIKHV
PGGGSVQIVY  KPVDLSKVTS  KCGSLGNIHH  KPGGGQVEVK  SEKLDFKDRV
QSKIGSLDNI  THVPGGGNKK  IETHKLTFRE  NAKAKTDHGA  EIVYKSPVVS
GDTSPRHLSN  VSSTGSIDMV  DSPQLATLAD  EVSASLAKQG  L
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[0047]   The term "**Phospho-Tau**" or "**P-Tau**" refers to a Tau protein or peptide that has been phosphorylated at one or more serine or threonine residues. As used herein, the notation "{P}**Ser**" or "{P}**S**" denote the amino acid residue phosphoserine. For example, the notation "{P}Ser199" refers to a polypeptide portion of **SEQ ID NO:1** wherein the residue that corresponds to residue 199 of **SEQ ID NO:1** is a phosphoserine residue. In contrast, the notation "Ser199" refers to a polypeptide portion of **SEQ ID NO:1** wherein the residue that corresponds to residue 199 of **SEQ ID NO:1** is a serine residue.

[0048]   *Hyper*phosphorylation of Tau can result in the formation of insoluble self-assembling "tangles," referred to herein as "Tau aggregates," of paired helical filaments and straight filaments. Such Tau aggregates may be intracellular (*e.g.*, intraneuronal), but may also form outside of the cells. The presence of Tau aggregates impairs Tau's ability to stabilize microtubules and thus leads to microtubule disassembly, dendritic spinal collapse, and the degeneration of axons. Normal Tau contains, on average two phosphorylated sites;

the hyperphosphorylated Tau filaments average seven to eight phosphorylated sites. Hyperphosphorylated Tau is the main constituent of the intracellular neurofibrillary tangles that are a main hallmark of Alzheimer's Disease and other tauopathies. As used herein, the term "**Pathological Tau**" refers to the hyperphosphorylated Tau that is characteristic of Alzheimer's Disease and other tauopathies.

II.   The Preferred Antibody-Based Molecules of the Present Invention

[0049]   The "**antibody-based molecules**" of the present invention include antibodies that are capable of immunospecifically and selectively binding to the Asp421 Epitope of Tau, as well as fragments and derivatives thereof that exhibit such binding immunospecificity and selectively. As used herein, a molecule is said to be a "**fragment**" of another molecule if it is obtained through the actual fragmenting of such parental molecule (for example, a Fab or (Fab)$_2$ fragment), or if it comprises an amino acid sequence that comprises a portion of the amino acid sequence of such parental molecule. As used herein, a molecule is said to be a "**derivative**" of another molecule (or relevant portion thereof) if it is obtained through the actual chemical modification of such parental molecule or portion thereof, or if it comprises an amino acid sequence that is substantially similar to the amino acid sequence of such parental molecule or relevant portion thereof (for example differing by less than 30%, less than 20%, less than 10%, or less than 5% from such parental molecule or such relevant portion thereof, or by 10 amino acid residues, or by fewer than 10, 9, 8, 7, 6, 5, 4, 3 or 2 amino acid residues from such parental molecule or relevant portion thereof).

[0050]   As used herein, the term "**antibody**" refers to an intact immunoglobulin as well as a molecule having an epitope-binding fragment thereof. As used herein, the terms "fragment," region" and "domain" are generally intended to be synonymous, unless the context of their use indicates otherwise. Naturally occurring antibodies typically comprise a tetramer which is usually composed of at least two heavy (H) chains and at least two light (L) chains. Each heavy chain is comprised of a heavy chain variable region (abbreviated herein as a "VH region") and a heavy chain constant region, usually comprised of three domains (CH1, CH2 and CH3 domains). Heavy chains can be of any isotype, including IgG (IgG1, IgG2, IgG3 and IgG4 subtypes), IgA (IgA1 and IgA2 subtypes), IgM and IgE. Each light chain is comprised of a light chain variable region (abbreviated herein as a "VL region") and a light chain constant region (CL). Light chains include kappa chains and lambda chains. The heavy and light chain variable region is typically responsible for antigen recognition, while

the heavy and light chain constant region may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (*e.g.*, effector cells) and the first component (Clq) of the classical complement system. The VH and VL regions can be further subdivided into regions of hypervariability, termed "complementarity determining regions," or "CDRs," that are interspersed with regions of more conserved sequence, termed "framework regions" (FR). Each VH and VL region is composed of three CDR Domains and four FR Domains arranged from amino-terminus to carboxy-terminus in the following order: FR1-CDR1-FR2-CDR2-FR3-CDR3-FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. Of particular relevance are antibodies and their epitope-binding fragments that have been "isolated" so as to exist in a physical milieu distinct from that in which it may occur in nature or that have been modified so as to differ from a naturally-occurring antibody in amino acid sequence.

[0051]   Fragments of antibodies (including Fab and (Fab)$_2$ fragments) that exhibit epitope-binding ability can be obtained, for example, by protease cleavage of intact antibodies. More preferably, such fragments will be single domain antibody fragments, scFv molecules, and the epitope-binding domains of antibodies, *etc.*, that are formed using recombinant techniques. For example, although the two domains of the Fv fragment, the VL region and the VH region, are encoded by separate genes, such gene sequences or their encoding cDNA can be joined, using recombinant methods, by a flexible linker (typically of about 10, 12, 15 or more amino acid residues) that enables them to be made as a single protein chain in which the VL and VH regions associate to form monovalent epitope-binding molecules (known as single chain Fv (scFv) molecules; see e.g., Bird *et al.* (1988) "*Single-Chain Antigen-Binding Proteins*," Science 242:423-426; and Huston *et al.* (1988) "*Protein Engineering Of Antibody Binding Sites: Recovery Of Specific Activity In An Anti-Digoxin Single-Chain Fv Analogue Produced In Escherichia coli*," Proc. Natl. Acad. Sci. (U.S.A.) 85:5879-5883). Alternatively, by employing a flexible linker that is too short (*e.g.*, less than about 9 residues) to enable the VL and VH regions of a single polypeptide chain to associate together, one can form a bispecific antibody, diabody, or similar molecule (in which two such polypeptide chains associate together to form a bivalent epitope-binding molecule) (see for instance Holliger, P. *et al.* (1993) "*'Diabodies': Small Bivalent And Bispecific Antibody Fragments*," Proc. Natl. Acad. Sci. (U.S.A.) 90(14), 6444-8 (1993) for a description of diabodies). Single domain antibody fragments possess only one variable domain (*e.g.*, VL or VH). Examples of the epitope-binding fragments encompassed within the present invention

include (i) Fab' or Fab fragments, a monovalent fragment consisting of the VL, VN, CL and CH1 domains, or a monovalent antibody as described in WO2007059782; (ii) F(ab')₂ fragments, bivalent fragments comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) Fd fragments consisting essentially of the VH and CH1 domains; (iv) Fv fragments consisting essentially of a VL and VH domain, (v) dAb fragments (Ward, E.S. *et al. "Binding Activities Of A Repertoire Of Single Immunoglobulin Variable Domains Secreted From Escherichia coli,"* Nature 341:544-546 (1989)), which consist essentially of a VH domain and also called domain antibodies (Holt, L.J. *et al.* (2003) *"Domain Antibodies: Proteins For Therapy,"* Trends Biotechnol. 21(11):484-490); (vi) camelid or nanobodies (Revets, H. *et al.* (2005) *"Nanobodies As Novel Agents For Cancer Therapy,"* Expert Opin. Biol. Ther. 5(l):111-124) and (vii) isolated complementarity determining regions (CDR). Furthermore, although the two domains of the Fv fragment, VL and VH, are coded for by separate genes, they may be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the VL and VH regions pair to form monovalent molecules (known as single-chain antibodies or single-chain Fv (scFv), see for instance Bird *et al.* (1988) *"Single-Chain Antigen-Binding Proteins,"* Science 242:423-426 and Huston *et al.* (1988) *"Protein Engineering Of Antibody Binding Sites: Recovery Of Specific Activity In An Anti-Digoxin Single-Chain Fv Analogue Produced In Escherichia coli,"* Proc. Natl. Acad. Sci. (U.S.A.) 85:5879-5883). These and other useful antibody fragments in the context of the present invention are discussed further herein. It also should be understood that the term antibody, unless specified otherwise, also includes antibody-like polypeptides, such as chimeric antibodies and humanized antibodies, and antibody fragments retaining the ability to specifically bind to the antigen (antigen-binding fragments) provided by any known technique, such as enzymatic cleavage, peptide synthesis, and recombinant techniques. An antibody as generated can possess any isotype. As used herein, "isotype" refers to the immunoglobulin class (for instance IgGl, IgG2, IgG3, IgG4, IgD, IgA, IgE, or IgM) that is encoded by heavy chain constant region genes. The choice of isotype typically will be guided by the desired effector functions, such as ADCC induction. Exemplary isotypes are IgGl, IgG2, IgG3, and IgG4. Either of the human light chain constant regions, kappa or lambda, may be used. If desired, the class of an anti-Tau antibody of the present invention may be switched by known methods. For example, an antibody of the present invention that was originally IgM may be class switched to an IgG antibody of the present invention. Further, class switching techniques may be used to convert one IgG subclass to another, for instance from IgGl to IgG2. Thus, the effector function of the antibodies of the

present invention may be changed by isotype switching to, e.g., an IgG1, IgG2, IgG3, IgG4, IgD, IgA, IgE, or IgM antibody for various therapeutic uses. In one embodiment an antibody of the present invention is an IgG1 antibody, for instance an IgG1, κ.

[0052] Such antibody fragments are obtained using conventional techniques known to those of skill in the art. For example, F(ab')2 fragments may be generated by treating antibody with pepsin. The resulting F(ab')2 fragment may be treated to reduce disulfide bridges to produce Fab' fragments. Fab fragments may be obtained by treating an IgG antibody with papain; Fab' fragments may be obtained with pepsin digestion of IgG antibody. An F(ab') fragment may also be produced by binding Fab' described below via a thioether bond or a disulfide bond. A Fab' fragment is an antibody fragment obtained by cutting a disulfide bond of the hinge region of the $F(ab')_2$. A Fab' fragment may be obtained by treating an $F(ab')_2$ fragment with a reducing agent, such as dithiothreitol. Antibody fragment may also be generated by expression of nucleic acids encoding such fragments in recombinant cells (see for instance Evans, M.J. *et al.* (1995) *"Rapid Expression Of An Anti-Human C5 Chimeric Fab Utilizing A Vector That Replicates In COS And 293 Cells,"* J. Immunol. Meth. 184:123-38). For example, a chimeric gene encoding a portion of an $F(ab')_2$ fragment could include DNA sequences encoding the CH1 domain and hinge region of the H chain, followed by a translational stop codon to yield such a truncated antibody fragment molecule. Suitable fragments capable of binding to a desired epitope may be readily screened for utility in the same manner as an intact antibody.

[0053] In one embodiment, such antibody fragments are a monovalent antibody, preferably a monovalent antibody as described in PCT Publication WO 2007/059782 (which is incorporated herein by reference in its entirety) having a deletion of the hinge region. Such an antibody may be constructed by a method comprising: i) providing a nucleic acid construct encoding the light chain of said monovalent antibody, said construct comprising a nucleotide sequence encoding the VL region of a selected antigen-specific anti-alpha-synuclein antibody and a nucleotide sequence encoding the constant CL region of an Ig, wherein said nucleotide sequence encoding the VL region of a selected antigen-specific antibody and said nucleotide sequence encoding the CL region of an Ig are operably linked together, and wherein, in case of an IgG1 subtype, the nucleotide sequence encoding the CL region has been modified such that the CL region does not contain any amino acids capable of forming disulfide bonds or covalent bonds with other peptides comprising an identical amino acid sequence of the CL

region in the presence of polyclonal human IgG or when administered to an animal or human being; ii) providing a nucleic acid construct encoding the heavy chain of said monovalent antibody, said construct comprising a nucleotide sequence encoding the VH region of a selected antigen-specific antibody and a nucleotide sequence encoding a constant CH region of a human Ig, wherein the nucleotide sequence encoding the CH region has been modified such that the region corresponding to the hinge region and, as required by the Ig subtype, other regions of the CH region, such as the CH3 region, does not comprise any amino acid residues which participate in the formation of disulfide bonds or covalent or stable non-covalent inter-heavy chain bonds with other peptides comprising an identical amino acid sequence of the CH region of the human Ig in the presence of polyclonal human IgG or when administered to an animal human being, wherein said nucleotide sequence encoding the VH region of a selected antigen-specific antibody and said nucleotide sequence encoding the CH region of said Ig are operably linked together; iii) providing a cell expression system for producing said monovalent antibody; iv) producing said monovalent antibody by co-expressing the nucleic acid constructs of (i) and (ii) in cells of the cell expression system of (iii).

[0054]   Similarly, in one embodiment, the antibody is a monovalent antibody, which comprises:

(i)   a variable region of an antibody of the invention as described herein or an antigen-binding part of the said region, and

(ii)   a CH region of an immunoglobulin or a fragment thereof comprising the CH2 and CH3 regions, wherein the CH region or fragment thereof has been modified such that the region corresponding to the hinge region and, if the immunoglobulin is not an IgG4 subtype, other regions of the CH region, such as the CH3 region, do not comprise any amino acid residues, which are capable of forming disulfide bonds with an identical CH region or other covalent or stable non-covalent inter-heavy chain bonds with an identical CH region in the presence of polyclonal human IgG.

[0055]   In a further embodiment, the heavy chain of the monovalent antibody has been modified such that the entire hinge has been deleted.

[0056]   In another further embodiment, the sequence of said monovalent antibody has been modified so that it does not comprise any acceptor sites for N-linked glycosylation.

[0057]   As used herein, an antibody or an epitope-binding fragment thereof is said to "**immunospecifically**" bind a region of another molecule (*i.e.*, an epitope) if it reacts or associates more frequently, more rapidly, with greater duration and/or with greater affinity or avidity with that epitope relative to alternative epitopes. It is also understood by reading this definition that, for example, an antibody or an epitope-binding fragment thereof that immunospecifically binds to a first target may or may not specifically or preferentially bind to a second target.

[0058]   As used herein, the term "**binding**" in the context of the binding of an antibody or binding fragment thereof to a predetermined antigen typically refers to binding with an affinity corresponding to a K_D of about 10^{-7} M or less, such as about 10^{-8} M or less, such as about 10^{-9} M or less when determined by, for instance, surface plasmon resonance (SPR) technology in a BIAcore 3000 instrument (preferably using the antibody as the ligand and the antigen as the analyte), and which binds to the predetermined antigen with an affinity corresponding to a K_D that is at least ten-fold lower, such as at least 100 fold lower, for instance at least 1,000 fold lower, such as at least 10,000 fold lower, for instance at least 100,000 fold lower than its affinity for binding to a non-specific antigen (*e.g.*, bovine serum albumin ("BSA"), casein, *etc.*) other than the predetermined antigen or a closely-related antigen. The amount with which the affinity is lower is dependent on the K_D of the antibody, so that when the K_D of the antibody is very low (that is, the antibody is highly specific), then the amount with which the affinity for the antigen is lower than the affinity for a non-specific antigen may be at least 10,000 fold. The term "k_d" (sec $^{-1}$ or 1/s), as used herein, refers to the dissociation rate constant of a particular antibody-antigen interaction. Said value is also referred to as the k_{off} value. The term "k_a" (M^{-1} x sec^{-1} or 1/M), as used herein, refers to the association rate constant of a particular antibody-antigen interaction. The term "K_D" (M), as used herein, refers to the dissociation equilibrium constant of a particular antibody-antigen interaction and is obtained by dividing the k_d by the k_a. The term "K_A" (M^{-1} or 1/M), as used herein, refers to the association equilibrium constant of a particular antibody-antigen interaction and is obtained by dividing the k_a by the k_d.

[0059]   As used herein, an antibody or an epitope-binding fragment thereof is said to "**selectively**" bind to a truncated peptide epitope if it immunospecifically binds to such epitope with higher affinity than it binds (if it binds at all) to the non-truncated peptide epitope. As used herein, the term "**truncated epitope**" denotes an epitope that is a portion of

a naturally-occurring ("**non-truncated**") epitope, such that the non-truncated epitope possesses one or more amino acid residues extending from the C-terminus and/or the N-terminus of the truncated epitope. Most preferably, such higher affinity will be at least 10-fold higher, at least 30-fold higher, at least 100-fold higher, at least 300-fold higher, at least 1,000-fold higher, at least 3,000-fold higher, or at least 10,000-fold higher. The extent of "selectivity" of an antibody, or of an epitope-binding fragment thereof, for truncated Tau is determined by comparing, via ELISA or Biacore, the affinity with which it immunospecifically binds to the truncated epitope relative to the non-truncated epitope thereof. For example, a polypeptide that comprises a "**Non-Truncated Asp421 Epitope**" possesses a Tau epitope that comprises position Asp421 of **SEQ ID NO:1**. A polypeptide that comprises a "**Truncated Asp421 Epitope**" possesses a Tau epitope that comprises position Asp421 of **SEQ ID NO:1**, wherein such Asp421 residue is the N-terminal or C-terminal Tau residue of such polypeptide. An antibody that exhibits immunospecificity for the Truncated Asp421 Epitope exhibits enhanced immunospecificity to the Truncated Asp421 Epitope relative to a Non-Truncated Asp421 Epitope. Thus, an antibody that exhibits immunospecificity for the Truncated Asp421 Epitope exhibits substantially diminished binding to polypeptides that contain Tau sequence C-terminal to position Asp421 of Tau (**SEQ ID NO:1**).

[0060]   The term "**epitope**" refers to an antigenic determinant capable of being immunospecifically bound to an antibody. Epitopes usually comprise surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics. Conformational and non-conformational epitopes are distinguished in that the binding to the former, but not the latter, is lost in the presence of denaturing solvents. An epitope may comprise amino acid residues directly involved in the binding (also called the immunodominant component of the epitope) and other amino acid residues, which are not directly involved in the binding, such as amino acid residues that are effectively blocked by the specific antigen-binding peptide (in other words, the amino acid residue is within the footprint of the specific antigen-binding peptide).

[0061]   As used herein, the term "**epitope-binding fragment of an antibody**" means a fragment of an antibody capable of immunospecifically binding to an epitope. An epitope-binding fragment may contain 1, 2, 3, 4, 5 or all 6 of the CDR Domains of such antibody and,

although capable of immunospecifically binding to such epitope, may exhibit an immunospecificity, affinity or selectivity toward such epitope that differs from that of such antibody. Preferably, however, an epitope-binding fragment will contain all 6 of the CDR Domains of such antibody. An epitope-binding fragment of an antibody may be a single polypeptide chain (*e.g.*, an scFv), or may comprise two or more polypeptide chains, each having an amino-terminus and a carboxyl terminus (*e.g.*, a diabody, an Fab fragment, an (Fab)$_2$ fragment, *etc.*).

[0062]   The antibody-based molecules of the present invention, and their Tau epitope-binding fragments will preferably be "humanized," particularly if they are to be employed for therapeutic purposes. The term "humanized" refer to a chimeric molecule, generally prepared using recombinant techniques, having an antigen binding site derived from an immunoglobulin from a non-human species and a remaining immunoglobulin structure based upon the structure and /or sequence of a human immunoglobulin. The antigen-binding site may comprise either complete non-human antibody variable domains fused to human constant domains, or only the complementarity determining regions (CDRs) of such variable domains grafted to appropriate human framework regions of human variable domains. The framework residues of such humanized molecules may be wild-type (*e.g.*, fully human) or they may be modified to contain one or more amino acid substitutions not found in the human antibody whose sequence has served as the basis for humanization. Humanization lessens or eliminates the likelihood that a constant region of the molecule will act as an immunogen in human individuals, but the possibility of an immune response to the foreign variable region remains (LoBuglio, A.F. *et al.* (1989) "*Mouse/Human Chimeric Monoclonal Antibody In Man: Kinetics And Immune Response,*" Proc. Natl. Acad. Sci. (U.S.A.) 86:4220-4224). Another approach focuses not only on providing human-derived constant regions, but modifying the variable regions as well so as to reshape them as closely as possible to human form. It is known that the variable regions of both heavy and light chains contain three complementarity-determining regions (CDRs) which vary in response to the antigens in question and determine binding capability, flanked by four framework regions (FRs) which are relatively conserved in a given species and which putatively provide a scaffolding for the CDRs. When non-human antibodies are prepared with respect to a particular antigen, the variable regions can be "reshaped" or "humanized" by grafting CDRs derived from non-human antibody on the FRs present in the human antibody to be modified. Application of this approach to various antibodies has been reported by Sato, K. *et al.* (1993) Cancer Res

53:851-856. Riechmann, L. *et al.* (1988) *"Reshaping Human Antibodies for Therapy,"* Nature 332:323-327; Verhoeyen, M. *et al.* (1988) *"Reshaping Human Antibodies: Grafting An Antilysozyme Activity,"* Science 239:1534-1536; Kettleborough, C. A. *et al.* (1991) *"Humanization Of A Mouse Monoclonal Antibody By CDR-Grafting: The Importance Of Framework Residues On Loop Conformation,"* Protein Engineering 4:773-3783; Maeda, H. *et al.* (1991) *"Construction Of Reshaped Human Antibodies With HIV-Neutralizing Activity,"* Human Antibodies Hybridoma 2:124-134; Gorman, S. D. *et al.* (1991) *"Reshaping A Therapeutic CD4 Antibody,"* Proc. Natl. Acad. Sci. (U.S.A.) 88:4181-4185; Tempest, P.R. *et al.* (1991) *"Reshaping A Human Monoclonal Antibody To Inhibit Human Respiratory Syncytial Virus Infection in vivo,"* Bio/Technology 9:266-271; Co, M. S. *et al.* (1991) *"Humanized Antibodies For Antiviral Therapy,"* Proc. Natl. Acad. Sci. (U.S.A.) 88:2869-2873; Carter, P. *et al.* (1992) *"Humanization Of An Anti-p185her2 Antibody For Human Cancer Therapy,"* Proc. Natl. Acad. Sci. (U.S.A.) 89:4285-4289; and Co, M.S. *et al.* (1992) *"Chimeric And Humanized Antibodies With Specificity For The CD33 Antigen,"* J. Immunol. 148:1149-1154. In some embodiments, humanized antibodies preserve all CDR sequences (for example, a humanized mouse antibody which contains all six CDRs from the mouse antibodies). In other embodiments, humanized antibodies have one or more CDRs (one, two, three, four, five, six) which are altered with respect to the original antibody, which are also termed one or more CDRs "derived from" one or more CDRs from the original antibody. The ability to humanize an antigen is well-known (see, *e.g.*, US Patents No. 5,225,539; 5,530,101; 5,585,089; 5,859,205; 6,407,213; 6,881,557).

[0063]   In one embodiment, an antibody-based molecule of the invention is a human antibody. Suitable human antibodies may be generated using transgenic or transchromosomal mice carrying parts of the human immune system rather than the mouse system. Such transgenic and transchromosomic mice include mice referred to herein as HuMAb mice and KM mice, respectively, and are collectively referred to herein as "transgenic mice."

[0064]   The HuMAb mouse contains a human immunoglobulin gene minilocus that encodes unrearranged human heavy variable and constant (μ and Y) and light variable and constant (K) chain immunoglobulin sequences, together with targeted mutations that inactivate the endogenous μ and K chain loci (Lonberg, N. *et al.* (1994) *"Antigen-Specific Human Antibodies From Mice Comprising Four Distinct Genetic Modifications,"* Nature

368:856-859). Accordingly, such mice exhibit reduced expression of mouse IgM or IgK and in response to immunization, the introduced human heavy and light chain transgenes, undergo class switching and somatic mutation to generate high affinity human IgG, κ monoclonal antibodies (Lonberg, N. *et al.* (1994) *"Antigen-Specific Human Antibodies From Mice Comprising Four Distinct Genetic Modifications,"* Nature 368:856-859; Lonberg, N. (1994) *"Human Monoclonal Antibodies from Transgenic Mice,"* In: HANDBOOK EXPERIMENTAL PHARMACOLOGY, Volume 181 (Starke, K. *et al.*, Eds.) Springer-Verlag Berlin Heidelberg; Lonberg, N. *et al.* (1995) *"Human Antibodies From Transgenic Mice,"* Intern. Rev. Immunol. 13(1):65-93; Harding, F. *et al.* (1995) *"Class Switching In Human Immunoglobulin Transgenic Mice,"* Ann. N.Y. Acad. Sci 764:536-546). The preparation of HuMAb mice is described in detail in Taylor, L. *et al.* (1992) *"A Transgenic Mouse That Expresses A Diversity Of Human Sequence Heavy And Light Chain Immunoglobulins,"* Nucl. Acids Res. 20(23):6287-6295; Chen, J. *et al.* (1993) *"Immunoglobulin Gene Rearrangement In B Cell Deficient Mice Generated By Targeted Deletion Of The JH Locus,"* Int'l. Immunol. 5:647-656; Tuaillon, N. *et al.* (1994) *"Biased Utilization Of DHQ52 And JH4 Gene Segments In A Human Ig Transgenic Minilocus Is Independent Of Antigenic Selection,"* J. Immunol. 152:2912-2920; Taylor, L. et al. (1994) *"Human Immunoglobulin Transgenes Undergo Rearrangement, Somatic Mutation And Class Switching In Mice That Lack Endogenous IgM,"* Int'l. Immunol. 6:579-591; Fishwild, D. et al. (1996) *"High-Avidity Human IgG Kappa Monoclonal Antibodies From A Novel Strain Of Minilocus Transgenic Mice,"* Nature Biotechnol. 14:845-851; see also US Patents No. 5,545,806; 5,569,825; 5,625,126; 5,633,425; 5,789,650; 5,877,397; 5,661,016; 5,814,318; 5,874,299; 5,770,429; 5,545,807; PCT Publications WO 98/24884, WO 94/25585, WO 93/1227, WO 92/22645, WO 92/03918 and WO 01/09187).

[0065] The HCo7 mice have a JKD disruption in their endogenous light chain (kappa) genes (as described in Chen *et al.* (1993) *"B Cell Development In Mice That Lack One Or Both Immunoglobulin Kappa Light Chain Genes,"* EMBO J. 12:821-830), a CMD disruption in their endogenous heavy chain genes (as described in Example 1 of PCT Publication WO 01/14424), a KCo5 human kappa light chain transgene (as described in Fishwild, D. et al. (1996) *"High-Avidity Human Igg Kappa Monoclonal Antibodies From A Novel Strain Of Minilocus Transgenic Mice,"* Nature Biotechnol. 14:845-851), and a HCo7 human heavy chain transgene (as described in US Patent No. 5,770,429).

[0066]   The HCol2 mice have a JKD disruption in their endogenous light chain (kappa) genes (as described in Chen *et al.* (1993) "*B Cell Development In Mice That Lack One Or Both Immunoglobulin Kappa Light Chain Genes,*" EMBO J. 12:821-830), a CMD disruption in their endogenous heavy chain genes (as described in Example 1 of PCT Publication WO 01/14424), a KCo5 human kappa light chain transgene (as described in Fishwild, D. et al. (1996) "*High-Avidity Human Igg Kappa Monoclonal Antibodies From A Novel Strain Of Minilocus Transgenic Mice,*" Nature Biotechnol. 14:845-851), and a HCol2 human heavy chain transgene (as described in Example 2 of PCT Publication WO 01/14424).

[0067]   In the KM mouse strain, the endogenous mouse kappa light chain gene has been homozygously disrupted as described in Chen *et al.* (1993) "*B Cell Development In Mice That Lack One Or Both Immunoglobulin Kappa Light Chain Genes,*" EMBO J. 12:821-830) and the endogenous mouse heavy chain gene has been homozygously disrupted as described in Example 1 of PCT Publication WO 01/09187. This mouse strain carries a human kappa light chain transgene, KCo5, as described in Fishwild, D. et al. (1996) "*High-Avidity Human Igg Kappa Monoclonal Antibodies From A Novel Strain Of Minilocus Transgenic Mice,*" Nature Biotechnol. 14:845-851). This mouse strain also carries a human heavy chain transchromosome composed of chromosome 14 fragment hCF (SC20) as described in PCT Publication WO 02/43478.

[0068]   Splenocytes from these transgenic mice may be used to generate hybridomas that secrete human monoclonal antibodies according to well-known techniques. Human monoclonal or polyclonal antibodies of the present invention, or antibodies of the present invention originating from other species may also be generated transgenically through the generation of another non-human mammal or plant that is transgenic for the immunoglobulin heavy and light chain sequences of interest and production of the antibody in a recoverable form therefrom. In connection with the transgenic production in mammals, antibodies may be produced in, and recovered from, the milk of goats, cows, or other mammals. See for instance US Patents No. 5,827,690; 5,756,687; 5,750,172 and 5,741,957.

[0069]   In some antibodies only part of a CDR, 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 (see, Kabat *et al.* (1992)

SEQUENCES OF PROTEINS OF IMMUNOLOGICAL INTEREST, National Institutes of Health Publication No. 91-3242; Chothia, C. *et al.* (1987) *"Canonical Structures For The Hypervariable Regions Of Immunoglobulins,"* J. Mol. Biol. 196:901-917), by molecular modeling and/or empirically, or as described in Gonzales, N.R. *et al.* (2004) *"SDR Grafting Of A Murine Antibody Using Multiple Human Germline Templates To Minimize Its Immunogenicity,"* Mol. Immunol. 41:863-872. In such humanized antibodies at positions in which one or more donor CDR residues is absent or in which an entire donor CR 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. 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.

[0070]   The fact that a single amino acid alteration of a CDR residue can result in loss of functional binding (Rudikoff, S. *et al.* (1982) *"Single Amino Acid Substitution Altering Antigen-Binding Spec*ificity," Proc. Natl. Acad. Sci. (USA) 79(6):1979-1983) provides a means for systematically identifying alternative functional CDR sequences. In one preferred method for obtaining such variant CDRs, a polynucleotide encoding the CDR is mutagenized (for example via random mutagenesis or by a site-directed method (*e.g.*, polymerase chain-mediated amplification with primers that encode the mutated locus)) to produce a CDR having a substituted amino acid residue. By comparing the identity of the relevant residue in the original (functional) CDR sequence to the identity of the substituted (non-functional) variant CDR sequence, the BLOSUM62.iij substitution score for that substitution can be identified. The BLOSUM system provides a matrix of amino acid substitutions created by analyzing a database of sequences for trusted alignments (Eddy, S.R. (2004) *"Where Did The BLOSUM62 Alignment Score Matrix Come From?,"* Nature Biotech. 22(8):1035-1036; Henikoff, J.G. (1992) "Amino acid substitution matrices from protein blocks," Proc. Natl. Acad. Sci. (USA) 89:10915-10919; Karlin, S. *et al.* (1990) *"Methods For Assessing The Statistical Significance Of Molecular Sequence Features By Using General Scoring Schemes,"* Proc. Natl. Acad. Sci. (USA) 87:2264-2268; Altschul, S.F. (1991) *"Amino Acid Substitution Matrices From An Information Theoretic Perspective,"* J. Mol. Biol. 219, 555-

565.   Currently, the most advanced BLOSUM database is the BLOSUM62 database (BLOSUM62.iij). **Table 1** presents the BLOSUM62.iij substitution scores (the higher the score the more conservative the substitution and thus the more likely the substitution will not affect function). If an antigen-binding fragment comprising the resultant CDR fails to bind to ROR1, for example, then the BLOSUM62.iij substitution score is deemed to be insufficiently conservative, and a new candidate substitution is selected and produced having a higher substitution score. Thus, for example, if the original residue was glutamate (E), and the non-functional substitute residue was histidine (H), then the BLOSUM62.iij substitution score will be 0, and more conservative changes (such as to aspartate, asparagine, glutamine, or lysine) are preferred.

Table 1																			
	A	**R**	**N**	**D**	**C**	**Q**	**E**	**G**	**H**	**I**	**L**	**K**	**M**	**F**	**P**	**S**	**T**	**W**	**Y**	**V**
A	+4	-1	-2	-2	0	-1	-1	0	-2	-1	-1	-1	-1	-2	-1	+1	0	-3	-2	0
R	-1	+5	0	-2	-3	+1	0	-2	0	-3	-2	+2	-1	-3	-2	-1	-1	-3	-2	-3
N	-2	0	+6	+1	-3	0	0	0	+1	-3	-3	0	-2	-3	-2	+1	0	-4	-2	-3
D	-2	-2	+1	+6	-3	0	+2	-1	-1	-3	-4	-1	-3	-3	-1	0	-1	-4	-3	-3
C	0	-3	-3	-3	+9	-3	-4	-3	-3	-1	-1	-3	-1	-2	-3	-1	-1	-2	-2	-1
Q	-1	+1	0	0	-3	+5	+2	-2	0	-3	-2	+1	0	-3	-1	0	-1	-2	-1	-2
E	-1	0	0	+2	-4	+2	+5	-2	0	-3	-3	+1	-2	-3	-1	0	-1	-3	-2	-2
G	0	-2	0	-1	-3	-2	-2	+6	-2	-4	-4	-2	-3	-3	-2	0	-2	-2	-3	-3
H	-2	0	+1	-1	-3	0	0	-2	+8	-3	-3	-1	-2	-1	-2	-1	-2	-2	+2	-3
I	-1	-3	-3	-3	-1	-3	-3	-4	-3	+4	+2	-3	+1	0	-3	-2	-1	-3	-1	+3
L	-1	-2	-3	-4	-1	-2	-3	-4	-3	+2	+4	-2	+2	0	-3	-2	-1	-2	-1	+1
K	-1	+2	0	-1	-3	+1	+1	-2	-1	-3	-2	+5	-1	-3	-1	0	-1	-3	-2	-2
M	-1	-1	-2	-3	-1	0	-2	-3	-2	+1	+2	-1	+5	0	-2	-1	-1	-1	-1	+1
F	-2	-3	-3	-3	-2	-3	-3	-3	-1	0	0	-3	0	+6	-4	-2	-2	+1	+3	-1
P	-1	-2	-2	-1	-3	-1	-1	-2	-2	-3	-3	-1	-2	-4	+7	-1	-1	-4	-3	-2
S	+1	-1	+1	0	-1	0	0	0	-1	-2	-2	0	-1	-2	-1	+4	+1	-3	-2	-2
T	0	-1	0	-1	-1	-1	-1	-2	-2	-1	-1	-1	-1	-2	-1	+1	+5	-2	-2	0
W	-3	-3	-4	-4	-2	-2	-3	-2	-2	-3	-2	-3	-1	+1	-4	-3	-2	+11	+2	-3
Y	-2	-2	-2	-3	-2	-1	-2	-3	+2	-1	-1	-2	-1	+3	-3	-2	-2	+2	+7	-1
V	0	-3	-3	-3	-1	-2	-2	-3	-3	+3	+1	-2	+1	-1	-2	-2	0	-3	-1	+4

[0071]   The invention thus contemplates the use of guided or random mutagenesis to identify improved CDRs.

[0072]   In the context of the present invention, conservative substitutions may be defined by substitutions within the classes of amino acids reflected in one or more of the following three tables:

Amino Acid Residue Classes For Conservative Substitutions:

Table 2	
Acidic Residues	Asp (D) and Glu (E)
Basic Residues	Lys (K), Arg (R), and His (H)
Hydrophilic Uncharged Residues	Ser (S), Thr (T), Asn (N), and Gln (Q)
Aliphatic Uncharged Residues	Gly (G), Ala (A), Val (V), Leu (L), and Ile (I)
Non-polar Uncharged Residues	Cys (C), Met (M), and Pro (P)
Aromatic Residues	Phe (F), Tyr (Y), and Trp (W)

Alternative Conservative Amino Acid Residue Substitution Classes:

Table 3			
1	A	S	T
2	D	E	
3	N	Q	
4	R	K	
5	I	L	M
6	F	Y	W

Alternative Physical and Functional Classifications of Amino Acid Residues:

Table 4	
Alcohol Group-Containing Residues	S and T
Aliphatic Residues	I, L, V and M
Cycloalkenyl-Associated Residues	F, H, W and Y
Hydrophobic Residues	A, C, F, G, H, I, L, M, R, T, V, W and Y
Negatively Charged Residues	D and E
Polar Residues	C, D, E, H, K, N, Q, R, S and T
Positively Charged Residues	H, K and R
Small Residues	A, C, D, G, N, P, S, T and V
Very Small Residues	A, G and S
Residues Involved In Turn Formation	A, C, D, E, G, H, K, N, Q, R, S, P and T
Flexible Residues	Q, T, K, S, G, P, D, E and R

[0073]   More conservative substitutions groupings include: valine-leucine-isoleucine, phenylalanine-tyrosine, lysine-arginine, alanine-valine, and asparagine-glutamine.

[0074]   Additional groups of amino acids may also be formulated using the principles described in, e.g., Creighton (1984) PROTEINS: STRUCTURE AND MOLECULAR PROPERTIES (2d Ed. 1993), W. H. Freeman and Company.

[0075]   Phage display technology can alternatively be used to increase (or decrease) CDR affinity. This technology, referred to as affinity maturation, employs mutagenesis or "CDR walking" and re-selection uses the target antigen or an antigenic fragment thereof to identify antibodies having CDRs that bind with higher (or lower) affinity to the antigen when compared with the initial or parental antibody (See, *e.g.* Glaser *et al.* (1992) *"Antibody*

Engineering By Codon-Based Mutagenesis In A Filamentous Phage Vector System," J. Immunology 149:3903-3913). Mutagenizing entire codons rather than single nucleotides results in a semi-randomized repertoire of amino acid mutations. Libraries can be constructed consisting of a pool of variant clones each of which differs by a single amino acid alteration in a single CDR and which contain variants representing each possible amino acid substitution for each CDR residue. Mutants with increased (or decreased) binding affinity for the antigen can be screened by contacting the immobilized mutants with labeled antigen. Any screening method known in the art can be used to identify mutant antibodies with increased or decreased affinity to the antigen (*e.g.*, ELISA) (See Wu, H. *et al.* (1998) "*Stepwise In Vitro Affinity Maturation Of Vitaxin, An Alphav Beta3-Specific Humanized Mab*," Proc. Natl. Acad. Sci. (U.S.A.) 95:6037-6042; Yelton *et al.* (1995) "*Affinity Maturation Of The BR96 Anti-Carcinoma Antibody By Codon-Based Mutagenesis*," J. Immunology 155:1994). CDR walking, which randomizes the Light Chain, may be used (see, Schier, R. *et al.* (1996) "*Isolation Of Picomolar Affinity Anti-c-erbB-2 Single-Chain Fv By Molecular Evolution Of The Complementarity Determining Regions In The Center Of The Antibody Binding Site*," J. Mol. Biol. 263:551-567).

[0076]   Methods for accomplishing such affinity maturation are described for example in: Krause, J.C. *et al.* (2011) "*An Insertion Mutation That Distorts Antibody Binding Site Architecture Enhances Function Of A Human Antibody*," MBio. 2(1) pii: e00345-10. doi: 10.1128/mBio.00345-10; Kuan, C.T. *et al.* (2010) "*Affinity-Matured Anti-Glycoprotein NMB Recombinant Immunotoxins Targeting Malignant Gliomas And Melanomas*," Int. J. Cancer 10.1002/ijc.25645; Hackel, B.J. *et al.* (2010) "*Stability And CDR Composition Biases Enrich Binder Functionality Landscapes*," J. Mol. Biol. 401(1):84-96; Montgomery, D.L. *et al.* (2009) "*Affinity Maturation And Characterization Of A Human Monoclonal Antibody Against HIV-1 gp41*," MAbs 1(5):462-474; Gustchina, E. *et al.* (2009) "*Affinity Maturation By Targeted Diversification Of The CDR-H2 Loop Of A Monoclonal Fab Derived From A Synthetic Naïve Human Antibody Library And Directed Against The Internal Trimeric Coiled-Coil Of Gp41 Yields A Set Of Fabs With Improved HIV-1 Neutralization Potency And Breadth*," Virology 393(1):112-119; Finlay, W.J. *et al.* (2009) "*Affinity Maturation Of A Humanized Rat Antibody For Anti-RAGE Therapy: Comprehensive Mutagenesis Reveals A High Level Of Mutational Plasticity Both Inside And Outside The Complementarity-Determining Regions*," J. Mol. Biol. 388(3):541-558; Bostrom, J. *et al.* (2009) "*Improving Antibody Binding Affinity And Specificity For Therapeutic Development*," Methods Mol.

Biol. 525:353-376; Steidl, S. *et al.* (2008) "*In Vitro Affinity Maturation Of Human GM-CSF Antibodies By Targeted CDR-Diversification,*" Mol. Immunol. 46(1):135-144; and Barderas, R. *et al.* (2008) "*Affinity Maturation Of Antibodies Assisted By In Silico Modeling,*" Proc. Natl. Acad. Sci. (USA) 105(26):9029-9034.

[0077] The term "**transgenic non-human animal**" refers to a non-human animal having a genome comprising one or more human heavy and/or light chain transgenes or transchromosomes (either integrated or non-integrated into the animal's natural genomic DNA) and which is capable of expressing fully human antibodies. For example, a transgenic mouse can have a human light chain transgene and either a human heavy chain transgene or human heavy chain transchromosome, such that the mouse produces human anti-Tau antibody when immunized with Tau antigen and/or cells expressing Tau. The human heavy chain transgene may be integrated into the chromosomal DNA of the mouse, as is the case for transgenic mice, for instance HuMAb mice, such as HCo7 or HCol2 mice, or the human heavy chain transgene may be maintained extrachromosomally, as is the case for transchromosomal KM mice as described in PCT Publication WO 02/43478. Such transgenic and transchromosomal mice (collectively referred to herein as "transgenic mice") are capable of producing multiple isotypes of human monoclonal antibodies to a given antigen (such as IgG, IgA, IgM, IgD and/or IgE) by undergoing V-D-J recombination and isotype switching.

[0078] The use of the antibody-based molecules of the present invention as Tau imaging probes has great potential due to their specificity. Because of the general impermeability of the blood-brain barrier, smaller single-chain variable antibody fragments (scFv molecules) have been found to be preferred as *in vivo* imaging ligands to detect Tau lesions. scFv molecules are formed as a fusion protein of the variable regions of the heavy (H) and light chains (L) domains of an antibody, connected to one another via a short linker peptide of from about 10 to about 25 amino acid residues. The linker is usually rich in glycine for flexibility (*e.g.*, GGGGSGGGGSGGGGS (**SEQ ID NO:2**) (Fisher, A. *et al.* (2009) "*Efficient Isolation Of Soluble Intracellular Single-Chain Antibodies Using The Twin-Arginine Translocation Machinery,*" J. Nol. Biol. 385(1):299-311; Bird, R.E. *et al.* (1988) "*Single-Chain Antigen-Binding Proteins,*" Science 242:423-426; Huston, J.S. *et al.* (1988) "*Protein Engineering Of Antibody Binding Sites: Recovery Of Specific Activity In An Anti-Digoxin Single-Chain Fv Analogue Produced In Escherichia coli,*" Proc. Natl. Acad. Sci. (U.S.A.) 85:5879-5883), as well as serine or threonine for solubility, and can either connect the N-

terminus of the Heavy Chain Variable Domain with the C-terminus of the Light Chain Variable Domain VL, or *vice versa* (Huang, L. *et al.* (2013) *"Single-Chain Fragment Variable Passive Immunotherapies For Neurodegenerative Diseases,"* Int. J. Mol. Sci. 14(9):19109-19127; Ahmad, Z.A. *et al.* (2012) *"scFv Antibody: Principles And Clinical Application,"* Clin. Dev. Immunol. 2012:980250; Huhalov, A. *et al.* (2004) *"Engineered Single-Chain Antibody Fragments For Radioimmunotherapy,"* Q. J. Nucl. Med. Mol. Imaging 48(4):279-288). An example of such a linker is GSTSGSGKPGSGEGSTKG (**SEQ ID NO:3**) (Whitlow, M. *et al.* (1993) *"An Improved Linker For Single-Chain Fv With Reduced Aggregation And Enhanced Proteolytic Stability,"* Protein Eng. 6:989–995). A particularly preferred linker for the present invention has the amino acid sequence (**SEQ ID NO:4**): SSGGGGSGGGGGGSSRSS.

[0079]   In order to facilitate purification and/or recovery, the scFv may include a poly histidine ("**His-Tag**") (*e.g.*, (**SEQ ID NO:5**) HHHHHH). The imidazole side chains of the histidine residues of the His-Tag can engage in reversible coordinative bonds to certain transition metal ions, such as Co^{2+}, Zn^{2+} and especially Ni^{+2}. Thus, when His-tagged scFv molecules are applied to a matrix containing such metal ions, they specifically bind to the matrix, while most untagged proteins do not. The scFv may additionally or alternatively include an "**HA-Tag**" such as (**SEQ ID NO:6**) GAYPYDVPDYAS. Human influenza hemagglutinin (HA) is a surface glycoprotein required for the infectivity of the human virus. The HA-tag is derived from the human influenza hemagglutinin (HA) surface glycoprotein, and permits detection of the scFv using an anti-HA-Tag antibody (Millipore).

[0080]   scFv molecules may be expressed directly or as a fusion protein that is linked to an N-terminal leader peptide that is cleaved in order to yield the scFv (see, *e.g.*, Huston, J.S. *et al.* (1988) *"Protein Engineering Of Antibody Binding Sites: Recovery Of Specific Activity In An Anti-Digoxin Single-Chain Fv Analogue Produced In Escherichia coli,"* Proc. Natl. Acad. Sci. (U.S.A.) 85:5879-5883). For example, the scFv may be fused to the modified trp LE leader peptide (MLE)), and cleaved away by acid cleavage of the Asp-Pro peptide bond (Piszkiewicz, D. *et al.* (1970) *"Anomalous Cleavage Of Aspartyl-Proline Peptide Bonds During Amino Acid Sequence Determinations,"* Biochem. Biophys. Res. Commun. 40(5):1173-1178; Fraser, K.J. *et al.* (1972) *"Specific Cleavage Between Variable And Constant Domains Of Rabbit Antibody Light Chains By Dilute Acid Hydrolysis,"* Biochemistry 11(26):4974-4977; Poulsen, K. *et al.* (1972) *"An Active Derivative Of Rabbit*

Antibody Light Chain Composed Of The Constant And The Variable Domains Held Together Only By A Native Disulfide Bond," Proc. Natl. Acad. Sci. (U.S.A.) 69(9):2495-2499).

[0081] In a further embodiment, an scFv can be linked to another scFv (which may be the same or different) in order to form a bivalent molecule. This can be done by producing a single peptide chain with two VH and two VL regions, yielding tandem scFv molecules (Xiong, C.-Y. *et al.* (2006) *"Development Of Tumor Targeting Anti-MUC-1 Multimer: Effects Of di-scFv Unpaired* Cysteine *Location On PEGylation And Tumor Binding,"* Protein Engineering Design and Selection 19(8):359-367; Kufer, P. *et al.* (2004) *"A Revival Of Bispecific Antibodies,"* Trends in Biotechnology 22(5):238-24). Alternatively, by forming an scFv whose Heavy Chain Variable Domain is separated from its Light Chain Variable Domain by a linker that is too short to permit such domains to complex with one another and form an epitope-binding site, one can force two scFv molecules to dimerize as a diabody (Hollinger, P. *et al.* (1993) *"Diabodies": Small Bivalent And Bispecific Antibody Fragments,"* Proc. Natl. Acad. Sci. (U.S.A.) 90(14):6444-6448). Diabodies have been shown to have dissociation constants up to 40-fold lower than corresponding scFv molecules, meaning that they have a much higher affinity to their target. Consequently, diabody drugs could be dosed much lower than other therapeutic antibodies and are capable of highly specific targeting of tumors in vivo (Adams, G.P. *et al.* (1998) *"Prolonged in vivo Tumour Retention Of A Human Diabody Targeting The Extracellular Domain Of Human HER2/neu,"* Brit. J. Cancer 77(9):1405-1412). Still shorter linkers (one or two amino acids) lead to the formation of trimers, so-called triabodies or tribodies. Tetrabodies have also been produced. They exhibit an even higher affinity to their targets than diabodies (Le Gall, F. *et al.* (1999) *"Di-, Tri- And Tetrameric Single-Chain Fv Antibody Fragments Against Human CD19: Effect Of Valency On Cell Binding,"* FEBS Letters 453(1):164-168). All of these formats can be composed from variable scFv molecules so as to form dimers, trimers, *etc.* having specificity for two or more different epitopes (*i.e.*, bispecific diabodies, *etc.*) (Dincq, S. *et al.* (2001) *"Expression And Purification Of Monospecific And Bispecific Recombinant Antibody Fragments Derived From Antibodies That Block The CD80/CD86-CD28 Costimulatory Pathway,"* Protein Express. Purificat. 22(1):11-24).

[0082] As discussed above, the formation of neurofibrillary tangles (NFT), which comprise an accumulation of hyperphosphorylated Tau protein, is a characteristic feature of neurodegenerative diseases such as Alzheimer's disease, Pick's disease and progressive

supranuclear palsy. The proteolytic cleavage of Tau at Asp421 (*i.e.*, at residue D421 of **SEQ ID NO:1**) as an effect of caspase activation results in the generation of truncated Tau that is known to further stimulate Tau polymerization and accelerate the development of NFTs. Thus, such cleavage is considered one of several mechanisms associated with the accumulation of hyperphosphorylated Tau (see Pedersen, J.T. *et al.* (2015) *"Tau Immunotherapy For Alzheimer's Disease,"* Trends Mol. Med. 2015 Apr 3. pii: S1471-4914(15)00058-1; pages 1-9, Jarero-Basulto, J.J. *et al.* (2013) *"Luna Proteolytic Cleavage Of Polymeric Tau Protein By Caspase-3: Implications For Alzheimer Disease,"* J. Neuropathol. Exp. Neurol. 72(12):1145-1161; Mondragón-Rodríguez, S. *et al.* (2014) *"Phosphorylation Of Tau Protein At Sites Ser(396-404) Is One Of The Earliest Events In Alzheimer's Disease And Down Syndrome,"* Neuropathol. Appl. Neurobiol. 40(2):121-135; Lerchundi, R. *et al.* (2011) *"Tau Cleavage At D421 By Caspase-3 Is Induced In Neurons And Astrocytes Infected With Herpes Simplex Virus Type 1,"* J. Alzheimers Dis. 23(3):513-520; Quintanilla, R.A. *et al.* (2009) *"Caspase-Cleaved Tau Expression Induces Mitochondrial Dysfunction In Immortalized Cortical Neurons: Implications For The Pathogenesis Of Alzheimer Disease,"* J. Biol. Chem. 284(28):18754-18766; Mondragón-Rodríguez, S. *et al.* (2008) *"Cleavage And Conformational Changes Of Tau Protein Follow Phosphorylation During Alzheimer's Disease,"* Int. J. Exp. Pathol. 89(2):81-90; Mondragón-Rodríguez, S. *et al.* (2008) *"Conformational Changes And Cleavage Of Tau In Pick Bodies Parallel The Early Processing Of Tau Found In Alzheimer Pathology,"* Neuropathol. Appl. Neurobiol. 34(1):62-75; Guillozet-Bongaarts, A.L. *et al.* (2006) *"Pseudophosphorylation Of Tau At Serine 422 Inhibits Caspase Cleavage: In Vitro Evidence And Implications For Tangle Formation in vivo,"* J. Neurochem. 97(4):1005-1014; Fasulo, L. *et al.* (2005) *"Apoptotic Effect Of Caspase-3 Cleaved Tau In Hippocampal Neurons And Its Potentiation By Tau FTDP-Mutation N279K,"* J. Alzheimers. Dis. 7(1):3-13; Guillozet-Bongaarts, A.L. *et al.* (2005) *"Tau Truncation During Neurofibrillary Tangle Evolution In Alzheimer's Disease,"* Neurobiol. Aging ;26(7):1015-1022; Cho, J.H. *et al.* (2004) *"Glycogen Synthase Kinase 3 Beta Induces Caspase-Cleaved Tau Aggregation In Situ,"* J. Biol. Chem. 279(52):54716-54723; and Berry, R.W. *et al.* (2003) *"Inhibition Of Tau Polymerization By Its Carboxy-Terminal Caspase Cleavage Fragment,"* Biochemistry 42(27):8325-8331, each of which references is hereby incorporated by reference herein in its entirety).

[0083]   The antibody-based molecules of the present invention exhibit immunospecificity to the "**Truncated Asp421 Epitope.**" Although any immunogen containing a free Asp421

residue (of **SEQ ID NO:1**) may be employed to isolate and characterize such antibodies, it is preferred to employ a peptide having the amino acid sequence of HLSNVSSTGSIDMVD (**SEQ ID NO:7**) which corresponds to amino acid residues 407-421 of Tau (**SEQ ID NO:1**). The employed immunogen may contain this peptide, and is preferably modified to contain an N-terminal cysteine residue that is conjugated to keyhole limpet hemocyanin (KLH). To screen antibodies that selectively recognize the free Asp421 residue, binding to this immunogen can be compared to a peptide that does not contain a free Asp421 residue such as HLSNVSSTGSIDMVDSP (**SEQ ID NO:105**), which corresponds to amino acid residues 407-423 of Tau (**SEQ ID NO:1**). Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 and Antibody 5G2G6 are illustrative antibodies that exhibit immunospecificity to the Truncated Asp421 Epitope.

A.   Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 and Antibody 5G2G6

[0084]   Such efforts led to the isolation of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 and Antibody 5G2G6, which immunospecifically binds to the Asp421 Epitope. Antibody 1G10D2, Antibody 5B3C11, Antibody 5G2A3 and Antibody 5G2G6 target the Truncated Asp421 Epitope and bind with a high affinity as determined by ELISA. Antibody 5G2A3 binds the Truncated Asp421 Epitope with high affinity (10^{-9} M) as determined using Biacore analysis. In contrast, Antibody 1G11A10 binds the Truncated Asp421 Epitope with lower affinity (10^{-6} M) as determined using Biacore analysis. Upon sequence analysis, Antibody 5G2A3 and Antibody 5G2G6 were found to be identical in sequence. Thus, further references to such antibodies will refer only to Antibody 5G2A3.

1.   Antibody 1G10D2

[0085]   The Light Chain Variable Domain of Antibody 1G10D2 has the amino acid sequence (**SEQ ID NO:8**; CDRs are underlined):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSIL  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVEAEDLGV  YYCFQGSHVP
WTFGGGTKLE  IK
```

[0086]   The Light Chain Variable Domain CDR1 of Antibody 1G10D2 thus has the amino acid sequence (**SEQ ID NO:9**): RSSQSILNSNGNTYLE

[0087]   The Light Chain Variable Domain CDR2 of Antibody 1G10D2 thus has the amino acid sequence (**SEQ ID NO:10**): KVSNRFS

[0088]   The Light Chain Variable Domain CDR3 of Antibody 1G10D2 thus has the amino acid sequence (**SEQ ID NO:11**): FQGSHVPWT

[0089]   The Heavy Chain Variable Domain of Antibody 1G10D2 has the amino acid sequence (**SEQ ID NO:12**; CDRs are underlined):

```
EVKLVESGGD LVTPGGSLKV SCAASGLTFS DSAMSWVRLT PEKRLEWVAS
ISTGGATYYP DGLKGRFTIS RDDARNILFL QMNSLRSEDT AMYYCTRRGV
SSGNLFTYWG QGTLVTVSA
```

[0090]   Thus, the Heavy Chain Variable Domain CDR1 of Antibody 1G10D2 has the amino acid sequence (**SEQ ID NO:13**): DSAMS

[0091]   Thus, the Heavy Chain Variable Domain CDR2 of Antibody 1G10D2 has the amino acid sequence (**SEQ ID NO:14**): SISTGGATYYPDGLKG

[0092]   Thus, the Heavy Chain Variable Domain CDR3 of Antibody 1G10D2 has the amino acid sequence (**SEQ ID NO:15**): RGVSSGNLFTY

2.   Antibody 1G11A10

[0093]   The Light Chain Variable Domain of Antibody 1G11A10 has the amino acid sequence (**SEQ ID NO:16**; CDRs are underlined):

```
DVLMTQTPLS LPVSLGDQAS ISCRSSQSII NSNGNTYLEW YLQKPGQSPK
LLIYKVSNRF SGVPDRFSGS GSGTDFTLKI SRVETEDLGI YYCFQGSHVP
WTFGGGTKLE IK
```

[0094]   The Light Chain Variable Domain CDR1 of Antibody 1G11A10 thus has the amino acid sequence (**SEQ ID NO:17**): RSSQSIINSNGNTYLE

[0095]   The Light Chain Variable Domain CDR2 of Antibody 1G11A10 thus has the amino acid sequence (**SEQ ID NO:18**): KVSNRFS

[0096]   The Light Chain Variable Domain CDR3 of Antibody 1G11A10 thus has the amino acid sequence (**SEQ ID NO:19**): FQGSHVPWT

[0097]   The Heavy Chain Variable Domain of Antibody 1G11A10 has the amino acid sequence (**SEQ ID NO:20**; CDRs are underlined):

```
EVKLVESGGG  LMKPGGSLKL  SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS
ISSGGQTYSP  DSVKGRFTIS  RDNARNILYL  QMRNLRSEDT  AMYYCASRGD
PTMTATLFVY  WGQGTLVTVS
```

[0098]   Thus, the Heavy Chain Variable Domain CDR1 of Antibody 1G11A10 has the amino acid sequence (**SEQ ID NO:21**): `SYAMS`

[0099]   Thus, the Heavy Chain Variable Domain CDR2 of Antibody 1G11A10 has the amino acid sequence (**SEQ ID NO:22**): `SISSGGQTYSPDSVKG`

[00100]   Thus, the Heavy Chain Variable Domain CDR3 of Antibody 1G11A10 has the amino acid sequence (**SEQ ID NO:23**): `RGDPTMTATLFVY`

3.   Antibody 5B3C11

[00101]   Occasionally, more than one antibody sequences may be expressed by the same hybridoma cell, which may result from the hybridoma being non-monoclonal or from a rearrangement issue or from the genetic background of fusion partner. In this case, two Light Chain Variable Domains were identified for Antibody 5B3C11: Light Chain VL1 and Light Chain VL2.

a. Light Chain VL1 of Antibody 5B3C11

[00102]   The Light Chain VL1 of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:24**; CDRs are underlined):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IK
```

[00103]   The Light Chain VL1 Variable Domain CDR1 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:25**): `RSNQSILHSNGNTYLD`

[00104]   The Light Chain VL1 Variable Domain CDR2 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:26**): `KVSNRFS`

[00105]   The Light Chain VL1 Variable Domain CDR3 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:27**): `FQGSHIPWT`

b. Light Chain VL2 of Antibody 5B3C11

[00106]   The Light Chain VL2 of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:28**; CDRs are underlined):

```
ENVLTQSPAI MSASPGEKVT MTCRASSSVS SSYLHWYQQK SGASPKLWIY
STSNLASGVP ARFSGSGSGT SYSLTISSVE AEDAATYYCQ QYSGYPRTFG
GGTKLEIK
```

[00107]   The Light Chain VL2 Variable Domain CDR1 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:29**): RASSSVSSSYLH

[00108]   The Light Chain VL2 Variable Domain CDR2 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:30**): STSNLAS

[00109]   The Light Chain VL2 Variable Domain CDR3 of Antibody 5B3C11 thus has the amino acid sequence (**SEQ ID NO:31**): QQYSGYPRT

[00110]   The Heavy Chain Variable Domain of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:32**; CDRs are underlined):

```
EVQLVESGGG LVKPGGSLKL SCAASGFTFS NYALSWVRQT PEKRLEWVAS
ISSGGNTYYP DSVKGRFTIS RDNARNILYL QMSSLRSEDT AMFYCTSRGD
TTLITTLFTY WGQGTLVTVS A
```

[00111]   Thus, the Heavy Chain Variable Domain CDR1 of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:33**): NYALS

[00112]   Thus, the Heavy Chain Variable Domain CDR2 of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:34**): SISSGGNTYYPDSVKG

[00113]   Thus, the Heavy Chain Variable Domain CDR3 of Antibody 5B3C11 has the amino acid sequence (**SEQ ID NO:35**): RGDTTLITTLFTY

4.   Antibody 5G2A3

[00114]   The Light Chain Variable Domain of Antibody 5G2A3 has the amino acid sequence (**SEQ ID NO:36**; CDRs are underlined):

```
DVLMTQTPLS LPVSLGDQAS ISCRSSQSIL HRNGNTYLDW FLLKPGQSPK
LLIYKVSNRF SGVPDRFSGS GSGTDFTLKI SRVEAEDLGV YYCFQGSHVP
WTFGGGTKLE IK
```

[00115]   The Light Chain Variable Domain CDR1 of Antibody 5G2A3 thus has the amino acid sequence (**SEQ ID NO:37**): RSSQSILHRNGNTYLD

[00116]   The Light Chain Variable Domain CDR2 of Antibody 5G2A3 thus has the amino acid sequence (**SEQ ID NO:38**): KVSNRFS

[00117] The Light Chain Variable Domain CDR3 of Antibody 5G2A3 thus has the amino acid sequence (**SEQ ID NO:39**): FQGSHVPWT

[00118] The Heavy Chain Variable Domain of Antibody 5G2A3 has the amino acid sequence (**SEQ ID NO:40**; CDRs are underlined):

```
EVKLVESGGG LVKPGGSLTL SCAASGFTFS SYAMSWVRQT PEKSLEWVAS
ISSGGNTFYP DTVKGRFTIS RDNARNILYL QMSGLRSEDT AIYYCARRGD
PNMITTLFGY WGQGTLVTIS A
```

[00119] Thus, the Heavy Chain Variable Domain CDR1 of Antibody 5G2A3 has the amino acid sequence (**SEQ ID NO:41**): SYAMS

[00120] Thus, the Heavy Chain Variable Domain CDR2 of Antibody 5G2A3 has the amino acid sequence (**SEQ ID NO:42**): SISSGGNTFYPDTVKG

[00121] Thus, the Heavy Chain Variable Domain CDR3 of Antibody 5G2A3 has the amino acid sequence (**SEQ ID NO:43**): RGDPNMITTLFGY

B.   scFv Molecules

[00122] scFv molecules may be generated from Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3, and will possess the same Light and Heavy Chain Variable Domains CDR1, CDR2 and CDR3 as such antibody. Peripheral injection of such scFv molecules results in a strong *in vivo* brain signal in transgenic tauopathy mice but not in wild-type or amyloid-β plaque mice. The imaging signal correlates very well with co-localization of the probe with intraneuronal Tau aggregates, and is associated with markers of endosomes, autophagosomes and lysosomes, suggesting their interaction in these degradation pathways. scFv molecules derived from Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3 have great potential as diagnostic markers for AD and related tauopathies.

[00123] In a preferred embodiment, such scFv molecules are prepared as a fusion protein that includes an N-terminal leader peptide portion having the amino acid sequence (**SEQ ID NO:44**): IQEEFKMKKTAIAIAVALAGFATVAQAA, and/or a C-terminal sequence peptide portion. The C-terminal peptide portion may include: an antibody constant domain, such as (**SEQ ID NO:45**): AKTTPPSVTSGQAGQ (Hussein, A.H. *et al.* (2007) *"Construction and Characterization of Single-Chain Variable Fragment Antibodies Directed against the Bordetella pertussis Surface Adhesins Filamentous Hemagglutinin and Pertactin,"* Infect.

Immun. 75(11):5476-5482), a His-Tag, such as (**SEQ ID NO:5**): HHHHHH), and/or an HA-Tag such as (**SEQ ID NO:6**): GAYPYDVPDYAS, or any combination or sub-combination thereof, and in any order. A preferred C-terminal peptide portion has the amino acid sequence (**SEQ ID NO:46**): AKTTPPSVTSGQAGQHHHHHHGAYPYDVPDYAS, and thus includes (in the N-terminus to C-Terminus direction) **SEQ ID NO:45, SEQ ID NO:5**, and **SEQ ID NO:6**.

1.   scFv Molecules Generated From Antibody 1G10D2

[00124]   The complete sequence of an exemplary scFv molecule generated from Antibody 1G10D2 is (**SEQ ID NO:47**) (CDR residues are underlined):

```
DVLMTQTPLS   LPVSLGDQAS   ISCRSSQSIL   NSNGNTYLEW   YLQKPGQSPK
LLIYKVSNRF   SGVPDRFSGS   GSGTDFTLKI   SRVEAEDLGV   YYCFQGSHVP
WTFGGGTKLE   IKssggggsg   gggggssrss   EVKLVESGGD   LVTPGGSLKV
SCAASGLTFS   DSAMSWVRLT   PEKRLEWVAS   ISTGGATYYP   DGLKGRFTIS
RDDARNILFL   QMNSLRSEDT   AMYYCTRRGV   SSGNLFTYWG   QGTLVTVSA
```

wherein amino acid residues 1-112 are the amino acid residues of the Light Chain Variable Domain of Antibody 1G10D2 (**SEQ ID NO:8**), amino acid residues 113-130 are the amino acid residues of the linker (**SEQ ID NO:4**) (shown in lowercase italics), and amino acid residues 131-249 are the amino acid residues of the Heavy Chain Variable Domain of Antibody 1G10D2 (**SEQ ID NO:12**).

[00125]   Thus, in preferred embodiments, such scFv fusion proteins will comprise the amino acid sequence of any of **SEQ ID NOs:48-56** (in which the N-terminal and/or C-Terminal peptide portions of the ScFv fusion are underlined):

SEQ ID NO:48 (a fusion of **SEQ ID NOs:44 and 57**):
```
IQEEFKMKKT   AIAIAVALAG   FATVAQAADV   LMTQTPLSLP   VSLGDQASIS
CRSSQSILNS   NGNTYLEWYL   QKPGQSPKLL   IYKVSNRFSG   VPDRFSGSGS
GTDFTLKISR   VEAEDLGVYY   CFQGSHVPWT   FGGGTKLEIK   ssggggsggg
gggssrssEV   KLVESGGDLV   TPGGSLKVSC   AASGLTFSDS   AMSWVRLTPE
KRLEWVASIS   TGGATYYPDG   LKGRFTISRD   DARNILFLQM   NSLRSEDTAM
YYCTRRGVSS   GNLFTYWGQG   TLVTVSA
```

SEQ ID NO:49 (a fusion of **SEQ ID NOs:47 and 45**):
```
DVLMTQTPLS   LPVSLGDQAS   ISCRSSQSIL   NSNGNTYLEW   YLQKPGQSPK
LLIYKVSNRF   SGVPDRFSGS   GSGTDFTLKI   SRVEAEDLGV   YYCFQGSHVP
WTFGGGTKLE   IKssggggsg   gggggssrss   EVKLVESGGD   LVTPGGSLKV
SCAASGLTFS   DSAMSWVRLT   PEKRLEWVAS   ISTGGATYYP   DGLKGRFTIS
RDDARNILFL   QMNSLRSEDT   AMYYCTRRGV   SSGNLFTYWG   QGTLVTVSAA
KTTPPSVTSG   QAGQ
```

SEQ ID NO:50 (a fusion of **SEQ ID NOs:47 and 5**):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSIL  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVEAEDLGV  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGD  LVTPGGSLKV
SCAASGLTFS  DSAMSWVRLT  PEKRLEWVAS  ISTGGATYYP  DGLKGRFTIS
RDDARNILFL  QMNSLRSEDT  AMYYCTRRGV  SSGNLFTYWG  QGTLVTVSAH
HHHHH
```

SEQ ID NO:51 (a fusion of **SEQ ID NOs:47 and 6**):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSIL  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVEAEDLGV  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGD  LVTPGGSLKV
SCAASGLTFS  DSAMSWVRLT  PEKRLEWVAS  ISTGGATYYP  DGLKGRFTIS
RDDARNILFL  QMNSLRSEDT  AMYYCTRRGV  SSGNLFTYWG  QGTLVTVSAG
AYPYDVPDYA  S
```

SEQ ID NO:52 (a fusion of **SEQ ID NOs:47 and 46**):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSIL  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVEAEDLGV  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGD  LVTPGGSLKV
SCAASGLTFS  DSAMSWVRLT  PEKRLEWVAS  ISTGGATYYP  DGLKGRFTIS
RDDARNILFL  QMNSLRSEDT  AMYYCTRRGV  SSGNLFTYWG  QGTLVTVSAA
KTTPPSVTSG  QAGQHHHHHH  GAYPYDVPDY  AS
```

SEQ ID NO:53 (a fusion of **SEQ ID NOs:44, 47 and 45**):

```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSSQSILNS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLKISR  VEAEDLGVYY  CFQGSHVPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  KLVESGGDLV  TPGGSLKVSC  AASGLTFSDS  AMSWVRLTPE
KRLEWVASIS  TGGATYYPDG  LKGRFTISRD  DARNILFLQM  NSLRSEDTAM
YYCTRRGVSS  GNLFTYWGQG  TLVTVSAAKT  TPPSVTSGQA  GQ
```

SEQ ID NO:54 (a fusion of **SEQ ID NOs:44, 47 and 5**):

```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSSQSILNS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLKISR  VEAEDLGVYY  CFQGSHVPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  KLVESGGDLV  TPGGSLKVSC  AASGLTFSDS  AMSWVRLTPE
KRLEWVASIS  TGGATYYPDG  LKGRFTISRD  DARNILFLQM  NSLRSEDTAM
YYCTRRGVSS  GNLFTYWGQG  TLVTVSAHHH  HHH
```

SEQ ID NO:55 (a fusion of **SEQ ID NOs:44, 47 and 6**):

```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSSQSILNS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLKISR  VEAEDLGVYY  CFQGSHVPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  KLVESGGDLV  TPGGSLKVSC  AASGLTFSDS  AMSWVRLTPE
KRLEWVASIS  TGGATYYPDG  LKGRFTISRD  DARNILFLQM  NSLRSEDTAM
YYCTRRGVSS  GNLFTYWGQG  TLVTVSAGAY  PYDVPDYAS
```

SEQ ID NO:56 (a fusion of **SEQ ID NOs:44, 47 and 46**):

```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSSQSILNS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
```

```
GTDFTLKISR  VEAEDLGVYY  CFQGSHVPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  KLVESGGDLV  TPGGSLKVSC  AASGLTFSDS  AMSWVRLTPE
KRLEWVASIS  TGGATYYPDG  LKGRFTISRD  DARNILFLQM  NSLRSEDTAM
YYCTRRGVSS  GNLFTYWGQG  TLVTVSAAKT  TPPSVTSGQA  GQHHHHHHGA
YPYDVPDYAS
```

2. scFv Molecules Generated From Antibody 1G11A10

[00126]   The complete sequence of an exemplary scFv molecule generated from Antibody 1G11A10 is (**SEQ ID NO:57**) (CDR residues are underlined):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSII  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVETEDLGI  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGG  LMKPGGSLKL
SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS  ISSGGQTYSP  DSVKGRFTIS
RDNARNILYL  QMRNLRSEDT  AMYYCASRGD  PTMTATLFVY  WGQGTLVTVS
```

wherein amino acid residues 1-112 are the amino acid residues of the Light Chain Variable Domain of Antibody 1G11A10 (**SEQ ID NO:16**), amino acid residues 113-130 are the amino acid residues of the linker (**SEQ ID NO:4**) (shown in lowercase italics), and amino acid residues 131-250 are the amino acid residues of the Heavy Chain Variable Domain of Antibody 1G11A10 (**SEQ ID NO:20**).

[00127]   Thus, in preferred embodiments, such scFv fusion proteins will comprise the amino acid sequence of any of **SEQ ID NOs:58-66** (in which the N-terminal and/or C-Terminal peptide portions of the ScFv fusion are underlined):

SEQ ID NO:58 (a fusion of SEQ ID NOs:44 and 57):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSSQSIINS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLKISR  VETEDLGIYY  CFQGSHVPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  KLVESGGGLM  KPGGSLKLSC  AASGFTFSSY  AMSWVRQSPE
KRLEWVASIS  SGGQTYSPDS  VKGRFTISRD  NARNILYLQM  RNLRSEDTAM
YYCASRGDPT  MTATLFVYWG  QGTLVTVS
```

SEQ ID NO:59 (a fusion of SEQ ID NOs:57 and 45):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSII  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVETEDLGI  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGG  LMKPGGSLKL
SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS  ISSGGQTYSP  DSVKGRFTIS
RDNARNILYL  QMRNLRSEDT  AMYYCASRGD  PTMTATLFVY  WGQGTLVTVS
AKTTPPSVTS  GQAGQ
```

SEQ ID NO:60 (a fusion of SEQ ID NOs:57 and 5):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSII  NSNGNTYLEW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVETEDLGI  YYCFQGSHVP
WTFGGGTKLE  IKssggggsg  ggggggssrss  EVKLVESGGG  LMKPGGSLKL
SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS  ISSGGQTYSP  DSVKGRFTIS
```

```
        RDNARNILYL  QMRNLRSEDT  AMYYCASRGD  PTMTATLFVY  WGQGTLVTVS
        HHHHHH
```

SEQ ID NO:61 (a fusion of **SEQ ID NOs:57 and 6**):
```
        DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSII  NSNGNTYLEW  YLQKPGQSPK
        LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVETEDLGI  YYCFQGSHVP
        WTFGGGTKLE  IKssgggsg    ggggssrss  EVKLVESGGG  LMKPGGSLKL
        SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS  ISSGGQTYSP  DSVKGRFTIS
        RDNARNILYL  QMRNLRSEDT  AMYYCASRGD  PTMTATLFVY  WGQGTLVTVS
        GAYPYDVPDY  AS
```

SEQ ID NO:62 (a fusion of **SEQ ID NOs:57 and 46**):
```
        DVLMTQTPLS  LPVSLGDQAS  ISCRSSQSII  NSNGNTYLEW  YLQKPGQSPK
        LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLKI  SRVETEDLGI  YYCFQGSHVP
        WTFGGGTKLE  IKssgggsg    ggggssrss  EVKLVESGGG  LMKPGGSLKL
        SCAASGFTFS  SYAMSWVRQS  PEKRLEWVAS  ISSGGQTYSP  DSVKGRFTIS
        RDNARNILYL  QMRNLRSEDT  AMYYCASRGD  PTMTATLFVY  WGQGTLVTVS
        AKTTPPSVTS  GQAGQHHHHH  HGAYPYDVPD  YAS
```

SEQ ID NO:63 (a fusion of **SEQ ID NOs:44, 57 and 45**):
```
        IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
        CRSSQSIINS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
        GTDFTLKISR  VETEDLGIYY  CFQGSHVPWT  FGGGTKLEIK  ssgggsggg
        gggssrssEV  KLVESGGGLM  KPGGSLKLSC  AASGFTFSSY  AMSWVRQSPE
        KRLEWVASIS  SGGQTYSPDS  VKGRFTISRD  NARNILYLQM  RNLRSEDTAM
        YYCASRGDPT  MTATLFVYWG  QGTLVTVSAK  TTPPSVTSGQ  AGQ
```

SEQ ID NO:64 (a fusion of **SEQ ID NOs:44, 57 and 5**):
```
        IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
        CRSSQSIINS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
        GTDFTLKISR  VETEDLGIYY  CFQGSHVPWT  FGGGTKLEIK  ssgggsggg
        gggssrssEV  KLVESGGGLM  KPGGSLKLSC  AASGFTFSSY  AMSWVRQSPE
        KRLEWVASIS  SGGQTYSPDS  VKGRFTISRD  NARNILYLQM  RNLRSEDTAM
        YYCASRGDPT  MTATLFVYWG  QGTLVTVSHH  HHHH
```

SEQ ID NO:65 (a fusion of **SEQ ID NOs:44, 57 and 6**):
```
        IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
        CRSSQSIINS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
        GTDFTLKISR  VETEDLGIYY  CFQGSHVPWT  FGGGTKLEIK  ssgggsggg
        gggssrssEV  KLVESGGGLM  KPGGSLKLSC  AASGFTFSSY  AMSWVRQSPE
        KRLEWVASIS  SGGQTYSPDS  VKGRFTISRD  NARNILYLQM  RNLRSEDTAM
        YYCASRGDPT  MTATLFVYWG  QGTLVTVSGA  YPYDVPDYAS
```

SEQ ID NO:66 (a fusion of **SEQ ID NOs:44, 57 and 46**):
```
        IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
        CRSSQSIINS  NGNTYLEWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
        GTDFTLKISR  VETEDLGIYY  CFQGSHVPWT  FGGGTKLEIK  ssgggsggg
        gggssrssEV  KLVESGGGLM  KPGGSLKLSC  AASGFTFSSY  AMSWVRQSPE
        KRLEWVASIS  SGGQTYSPDS  VKGRFTISRD  NARNILYLQM  RNLRSEDTAM
        YYCASRGDPT  MTATLFVYWG  QGTLVTVSAK  TTPPSVTSGQ  AGQHHHHHG
        AYPYDVPDYA  S
```

3. scFv Molecules Generated From Antibody 5B3C11

a. scFv Molecules Generated From Light Chain VL1 of Antibody 5B3C11

[00128]   The complete sequence of an exemplary scFv molecule generated from Antibody 5B3C11 using the VL1 Light Chain Variable Domain) is (**SEQ ID NO:67**) (CDR residues are underlined):

```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IKssggggsg  ggggssrss  EVQLVESGGG  LVKPGGSLKL
SCAASGFTFS  NYALSWVRQT  PEKRLEWVAS  ISSGGNTYYP  DSVKGRFTIS
RDNARNILYL  QMSSLRSEDT  AMFYCTSRGD  TTLITTLFTY  WGQGTLVTVS
A
```

wherein amino acid residues 1-112 are the amino acid residues of the VL1 Light Chain Variable Domain of the Antibody 5B3C11 (**SEQ ID NO:28**), amino acid residues 113-130 are the amino acid residues of the linker (**SEQ ID NO:4**) (shown in lowercase italics), and amino acid residues 131-251 are the amino acid residues of the Heavy Chain Variable Domain of Antibody 5B3C11 (**SEQ ID NO:32**).

[00129]   Thus, in preferred embodiments, such scFv fusion proteins will comprise the amino acid sequence of any of **SEQ ID NOs:68-76** (in which the N-terminal and/or C-Terminal peptide portions of the ScFv fusion are underlined):

SEQ ID NO:68 (a fusion of **SEQ ID NOs:44 and 67**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSNQSILHS  NGNTYLDWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLRISR  VEAEDLGVYY  CFQGSHIPWT  FGGGTKLEIK  ssggggsggg
gggssrssEV  QLVESGGGLV  KPGGSLKLSC  AASGFTFSNY  ALSWVRQTPE
KRLEWVASIS  SGGNTYYPDS  VKGRFTISRD  NARNILYLQM  SSLRSEDTAM
FYCTSRGDTT  LITTLFTYWG  QGTLVTVSA
```

SEQ ID NO:69 (a fusion of **SEQ ID NOs:67 and 45**):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IKssggggsg  ggggssrss  EVQLVESGGG  LVKPGGSLKL
SCAASGFTFS  NYALSWVRQT  PEKRLEWVAS  ISSGGNTYYP  DSVKGRFTIS
RDNARNILYL  QMSSLRSEDT  AMFYCTSRGD  TTLITTLFTY  WGQGTLVTVS
AAKTTPPSVT  SGQAGQ
```

SEQ ID NO:70 (a fusion of **SEQ ID NOs:67 and 5**):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IKssggggsg  ggggssrss  EVQLVESGGG  LVKPGGSLKL
SCAASGFTFS  NYALSWVRQT  PEKRLEWVAS  ISSGGNTYYP  DSVKGRFTIS
```

```
RDNARNILYL  QMSSLRSEDT  AMFYCTSRGD  TTLITTLFTY  WGQGTLVTVS
AHHHHHH
```

SEQ ID NO:71 (a fusion of **SEQ ID NOs:67 and 6**):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IKssgggggsg  gggggssrss  EVQLVESGGG  LVKPGGSLKL
SCAASGFTFS  NYALSWVRQT  PEKRLEWVAS  ISSGGNTYYP  DSVKGRFTIS
RDNARNILYL  QMSSLRSEDT  AMFYCTSRGD  TTLITTLFTY  WGQGTLVTVS
AGAYPYDVPD  YAS
```

SEQ ID NO:72 (a fusion of **SEQ ID NOs:67 and 46**):
```
DVLMTQTPLS  LPVSLGDQAS  ISCRSNQSIL  HSNGNTYLDW  YLQKPGQSPK
LLIYKVSNRF  SGVPDRFSGS  GSGTDFTLRI  SRVEAEDLGV  YYCFQGSHIP
WTFGGGTKLE  IKssgggggsg  gggggssrss  EVQLVESGGG  LVKPGGSLKL
SCAASGFTFS  NYALSWVRQT  PEKRLEWVAS  ISSGGNTYYP  DSVKGRFTIS
RDNARNILYL  QMSSLRSEDT  AMFYCTSRGD  TTLITTLFTY  WGQGTLVTVS
AAKTTPPSVT  SGQAGQHHHH  HHGAYPYDVP  DYAS
```

SEQ ID NO:73 (a fusion of **SEQ ID NOs:44, 67 and 45**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSNQSILHS  NGNTYLDWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLRISR  VEAEDLGVYY  CFQGSHIPWT  FGGGTKLEIK  ssgggggsggg
gggssrssEV  QLVESGGGLV  KPGGSLKLSC  AASGFTFSNY  ALSWVRQTPE
KRLEWVASIS  SGGNTYYPDS  VKGRFTISRD  NARNILYLQM  SSLRSEDTAM
FYCTSRGDTT  LITTLFTYWG  QGTLVTVSAA  KTTPPSVTSG  QAGQ
```

SEQ ID NO:74 (a fusion of **SEQ ID NOs:44, 67 and 5**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSNQSILHS  NGNTYLDWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLRISR  VEAEDLGVYY  CFQGSHIPWT  FGGGTKLEIK  ssgggggsggg
gggssrssEV  QLVESGGGLV  KPGGSLKLSC  AASGFTFSNY  ALSWVRQTPE
KRLEWVASIS  SGGNTYYPDS  VKGRFTISRD  NARNILYLQM  SSLRSEDTAM
FYCTSRGDTT  LITTLFTYWG  QGTLVTVSAH  HHHH
```

SEQ ID NO:75 (a fusion of **SEQ ID NOs:44, 67 and 6**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSNQSILHS  NGNTYLDWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLRISR  VEAEDLGVYY  CFQGSHIPWT  FGGGTKLEIK  ssgggggsggg
gggssrssEV  QLVESGGGLV  KPGGSLKLSC  AASGFTFSNY  ALSWVRQTPE
KRLEWVASIS  SGGNTYYPDS  VKGRFTISRD  NARNILYLQM  SSLRSEDTAM
FYCTSRGDTT  LITTLFTYWG  QGTLVTVSAG  AYPYDVPDYA  S
```

SEQ ID NO:76 (a fusion of **SEQ ID NOs:44, 67 and 46**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAADV  LMTQTPLSLP  VSLGDQASIS
CRSNQSILHS  NGNTYLDWYL  QKPGQSPKLL  IYKVSNRFSG  VPDRFSGSGS
GTDFTLRISR  VEAEDLGVYY  CFQGSHIPWT  FGGGTKLEIK  ssgggggsggg
gggssrssEV  QLVESGGGLV  KPGGSLKLSC  AASGFTFSNY  ALSWVRQTPE
KRLEWVASIS  SGGNTYYPDS  VKGRFTISRD  NARNILYLQM  SSLRSEDTAM
FYCTSRGDTT  LITTLFTYWG  QGTLVTVSAA  KTTPPSVTSG  QAGQHHHHHH
GAYPYDVPDY  AS
```

b. scFv Molecules Generated From Light Chain VL2 of Antibody 5B3C11

[00130]   The complete sequence of an exemplary scFv molecule generated from Antibody 5B3C11 using the VL2 Light Chain Variable Domain) is (**SEQ ID NO:77**) (CDR residues are underlined):

```
ENVLTQSPAI  MSASPGEKVT  MTCRASSSVS  SSYLHWYQQK  SGASPKLWIY
STSNLASGVP  ARFSGSGSGT  SYSLTISSVE  AEDAATYYCQ  QYSGYPRTFG
GGTKLEIKss  ggggsggggg  gssrssEVQL  VESGGGLVKP  GGSLKLSCAA
SGFTFSNYAL  SWVRQTPEKR  LEWVASISSG  GNTYYPDSVK  GRFTISRDNA
RNILYLQMSS  LRSEDTAMFY  CTSRGDTTLI  TTLFTYWGQG  TLVTVSA
```

wherein amino acid residues 1-108 are the amino acid residues of the VL2 Light Chain Variable Domain of Antibody 5B3C11 (**SEQ ID NO:28**), amino acid residues 109-126 are the amino acid residues of the linker (**SEQ ID NO:4**) (shown in lowercase italics), and amino acid residues 127-247 are the amino acid residues of the Heavy Chain Variable Domain of Antibody 5B3C11 (**SEQ ID NO:32**).

[00131]   Thus, in preferred embodiments, such scFv fusion proteins will comprise the amino acid sequence of any of **SEQ ID NOs:78-86** (in which the N-terminal and/or C-Terminal peptide portions of the ScFv fusion are underlined):

SEQ ID NO:78 (a fusion of **SEQ ID NOs:44 and 77**):
```
IQEEFKMKKT  AIAIAVALAG  FATVAQAAEN  VLTQSPAIMS  ASPGEKVTMT
CRASSSVSSS  YLHWYQQKSG  ASPKLWIYST  SNLASGVPAR  FSGSGSGTSY
SLTISSVEAE  DAATYYCQQY  SGYPRTFGGG  TKLEIKssgg  ggsgggggs
srssEVQLVE  SGGGLVKPGG  SLKLSCAASG  FTFSNYALSW  VRQTPEKRLE
WVASISSGGN  TYYPDSVKGR  FTISRDNARN  ILYLQMSSLR  SEDTAMFYCT
SRGDTTLITT  LFTYWGQGTL  VTVSA
```

SEQ ID NO:79 (a fusion of **SEQ ID NOs:77 and 45**):
```
ENVLTQSPAI  MSASPGEKVT  MTCRASSSVS  SSYLHWYQQK  SGASPKLWIY
STSNLASGVP  ARFSGSGSGT  SYSLTISSVE  AEDAATYYCQ  QYSGYPRTFG
GGTKLEIKss  ggggsggggg  gssrssEVQL  VESGGGLVKP  GGSLKLSCAA
SGFTFSNYAL  SWVRQTPEKR  LEWVASISSG  GNTYYPDSVK  GRFTISRDNA
RNILYLQMSS  LRSEDTAMFY  CTSRGDTTLI  TTLFTYWGQG  TLVTVSAAKT
TPPSVTSGQA  GQ
```

SEQ ID NO:80 (a fusion of **SEQ ID NOs:77 and 5**):
```
ENVLTQSPAI  MSASPGEKVT  MTCRASSSVS  SSYLHWYQQK  SGASPKLWIY
STSNLASGVP  ARFSGSGSGT  SYSLTISSVE  AEDAATYYCQ  QYSGYPRTFG
GGTKLEIKss  ggggsggggg  gssrssEVQL  VESGGGLVKP  GGSLKLSCAA
SGFTFSNYAL  SWVRQTPEKR  LEWVASISSG  GNTYYPDSVK  GRFTISRDNA
RNILYLQMSS  LRSEDTAMFY  CTSRGDTTLI  TTLFTYWGQG  TLVTVSAHHH
HHH
```

SEQ ID NO:81 (a fusion of **SEQ ID NOs:77 and 6**):

```
ENVLTQSPAI MSASPGEKVT MTCRASSSVS SSYLHWYQQK SGASPKLWIY
STSNLASGVP ARFSGSGSGT SYSLTISSVE AEDAATYYCQ QYSGYPRTFG
GGTKLEIKss ggggsggggg gssrssEVQL VESGGGLVKP GGSLKLSCAA
SGFTFSNYAL SWVRQTPEKR LEWVASISSG GNTYYPDSVK GRFTISRDNA
RNILYLQMSS LRSEDTAMFY CTSRGDTTLI TTLFTYWGQG TLVTVSAGAY
PYDVPDYAS
```

SEQ ID NO:82 (a fusion of **SEQ ID NOs:77 and 46**):

```
ENVLTQSPAI MSASPGEKVT MTCRASSSVS SSYLHWYQQK SGASPKLWIY
STSNLASGVP ARFSGSGSGT SYSLTISSVE AEDAATYYCQ QYSGYPRTFG
GGTKLEIKss ggggsggggg gssrssEVQL VESGGGLVKP GGSLKLSCAA
SGFTFSNYAL SWVRQTPEKR LEWVASISSG GNTYYPDSVK GRFTISRDNA
RNILYLQMSS LRSEDTAMFY CTSRGDTTLI TTLFTYWGQG TLVTVSAAKT
TPPSVTSGQA GQHHHHHHGA YPYDVPDYAS
```

SEQ ID NO:83 (a fusion of **SEQ ID NOs:44, 77 and 45**):

```
IQEEFKMKKT AIAIAVALAG FATVAQAAEN VLTQSPAIMS ASPGEKVTMT
CRASSSVSSS YLHWYQQKSG ASPKLWIYST SNLASGVPAR FSGSGSGTSY
SLTISSVEAE DAATYYCQQY SGYPRTFGGG TKLEIKssgg ggsgggggggs
srssEVQLVE SGGGLVKPGG SLKLSCAASG FTFSNYALSW VRQTPEKRLE
WVASISSGGN TYYPDSVKGR FTISRDNARN ILYLQMSSLR SEDTAMFYCT
SRGDTTLITT LFTYWGQGTL VTVSAAKTTP PSVTSGQAGQ
```

SEQ ID NO:84 (a fusion of **SEQ ID NOs:44, 77 and 5**):

```
IQEEFKMKKT AIAIAVALAG FATVAQAAEN VLTQSPAIMS ASPGEKVTMT
CRASSSVSSS YLHWYQQKSG ASPKLWIYST SNLASGVPAR FSGSGSGTSY
SLTISSVEAE DAATYYCQQY SGYPRTFGGG TKLEIKssgg ggsgggggggs
srssEVQLVE SGGGLVKPGG SLKLSCAASG FTFSNYALSW VRQTPEKRLE
WVASISSGGN TYYPDSVKGR FTISRDNARN ILYLQMSSLR SEDTAMFYCT
SRGDTTLITT LFTYWGQGTL VTVSAHHHHH H
```

SEQ ID NO:85 (a fusion of **SEQ ID NOs:44, 77 and 6**):

```
IQEEFKMKKT AIAIAVALAG FATVAQAAEN VLTQSPAIMS ASPGEKVTMT
CRASSSVSSS YLHWYQQKSG ASPKLWIYST SNLASGVPAR FSGSGSGTSY
SLTISSVEAE DAATYYCQQY SGYPRTFGGG TKLEIKssgg ggsgggggggs
srssEVQLVE SGGGLVKPGG SLKLSCAASG FTFSNYALSW VRQTPEKRLE
WVASISSGGN TYYPDSVKGR FTISRDNARN ILYLQMSSLR SEDTAMFYCT
SRGDTTLITT LFTYWGQGTL VTVSAGAYPY DVPDYAS
```

SEQ ID NO:86 (a fusion of **SEQ ID NOs:44, 77 and 46**):

```
IQEEFKMKKT AIAIAVALAG FATVAQAAEN VLTQSPAIMS ASPGEKVTMT
CRASSSVSSS YLHWYQQKSG ASPKLWIYST SNLASGVPAR FSGSGSGTSY
SLTISSVEAE DAATYYCQQY SGYPRTFGGG TKLEIKssgg ggsgggggggs
srssEVQLVE SGGGLVKPGG SLKLSCAASG FTFSNYALSW VRQTPEKRLE
WVASISSGGN TYYPDSVKGR FTISRDNARN ILYLQMSSLR SEDTAMFYCT
SRGDTTLITT LFTYWGQGTL VTVSAAKTTP PSVTSGQAGQ HHHHHHGAYP
YDVPDYAS
```

4.   scFv Molecules Generated From Antibody 5G2A3

[00132]   The complete sequence of an exemplary scFv molecule generated from Antibody 5G2A3 (or Antibody 5G2G6, which has the same sequence) is (**SEQ ID NO:87**) (CDR residues are underlined):

```
DVLMTQTPLS LPVSLGDQAS ISCRSSQSIL HRNGNTYLDW FLLKPGQSPK
LLIYKVSNRF SGVPDRFSGS GSGTDFTLKI SRVEAEDLGV YYCFQGSHVP
WTFGGGTKLE IKssggggsg ggggssrss EVKLVESGGG LVKPGGSLTL
SCAASGFTFS SYAMSWVRQT PEKSLEWVAS ISSGGNTFYP DTVKGRFTIS
RDNARNILYL QMSGLRSEDT AIYYCARRGD PNMITTLFGY WGQGTLVTIS
A
```

wherein amino acid residues 1-112 are the amino acid residues of the Light Chain Variable Domain of Antibody 5G2A3 (**SEQ ID NO:36**), amino acid residues 113-130 are the amino acid residues of the linker (**SEQ ID NO:4**) (shown in lowercase italics), and amino acid residues 131-251 are the amino acid residues of the Heavy Chain Variable Domain of Antibody 5G2A3 (**SEQ ID NO:40**).

[00133]   Thus, in preferred embodiments, such scFv fusion proteins will comprise the amino acid sequence of any of **SEQ ID NOs:96-104** (in which the N-terminal and/or C-Terminal peptide portions of the ScFv fusion are underlined):

SEQ ID NO:88 (a fusion of **SEQ ID NOs:44 and 87**):
```
IQEEFKMKKT AIAIAVALAG FATVAQAADV LMTQTPLSLP VSLGDQASIS
CRSSQSILHR NGNTYLDWFL LKPGQSPKLL IYKVSNRFSG VPDRFSGSGS
GTDFTLKISR VEAEDLGVYY CFQGSHVPWT FGGGTKLEIK ssggggsggg
gggssrssEV KLVESGGGLV KPGGSLTLSC AASGFTFSSY AMSWVRQTPE
KSLEWVASIS SGGNTFYPDT VKGRFTISRD NARNILYLQM SGLRSEDTAI
YYCARRGDPN MITTLFGYWG QGTLVTISA
```

SEQ ID NO:89 (a fusion of **SEQ ID NOs:87 and 45**):
```
DVLMTQTPLS LPVSLGDQAS ISCRSSQSIL HRNGNTYLDW FLLKPGQSPK
LLIYKVSNRF SGVPDRFSGS GSGTDFTLKI SRVEAEDLGV YYCFQGSHVP
WTFGGGTKLE IKssggggsg ggggssrss EVKLVESGGG LVKPGGSLTL
SCAASGFTFS SYAMSWVRQT PEKSLEWVAS ISSGGNTFYP DTVKGRFTIS
RDNARNILYL QMSGLRSEDT AIYYCARRGD PNMITTLFGY WGQGTLVTIS
AAKTTPPSVT SGQAGQ
```

SEQ ID NO:90 (a fusion of **SEQ ID NOs:87 and 5**):
```
DVLMTQTPLS LPVSLGDQAS ISCRSSQSIL HRNGNTYLDW FLLKPGQSPK
LLIYKVSNRF SGVPDRFSGS GSGTDFTLKI SRVEAEDLGV YYCFQGSHVP
WTFGGGTKLE IKssggggsg ggggssrss EVKLVESGGG LVKPGGSLTL
SCAASGFTFS SYAMSWVRQT PEKSLEWVAS ISSGGNTFYP DTVKGRFTIS
RDNARNILYL QMSGLRSEDT AIYYCARRGD PNMITTLFGY WGQGTLVTIS
AHHHHHH
```

SEQ ID NO:91 (a fusion of **SEQ ID NOs:87 and 6**):

```
DVLMTQTPLS   LPVSLGDQAS   ISCRSSQSIL   HRNGNTYLDW   FLLKPGQSPK
LLIYKVSNRF   SGVPDRFSGS   GSGTDFTLKI   SRVEAEDLGV   YYCFQGSHVP
WTFGGGTKLE   IKssggggsg   ggggssrss   EVKLVESGGG   LVKPGGSLTL
SCAASGFTFS   SYAMSWVRQT   PEKSLEWVAS   ISSGGNTFYP   DTVKGRFTIS
RDNARNILYL   QMSGLRSEDT   AIYYCARRGD   PNMITTLFGY   WGQGTLVTIS
AGAYPYDVPD   YAS
```

SEQ ID NO:92 (a fusion of **SEQ ID NOs:87 and 46**):

```
DVLMTQTPLS   LPVSLGDQAS   ISCRSSQSIL   HRNGNTYLDW   FLLKPGQSPK
LLIYKVSNRF   SGVPDRFSGS   GSGTDFTLKI   SRVEAEDLGV   YYCFQGSHVP
WTFGGGTKLE   IKssggggsg   ggggssrss   EVKLVESGGG   LVKPGGSLTL
SCAASGFTFS   SYAMSWVRQT   PEKSLEWVAS   ISSGGNTFYP   DTVKGRFTIS
RDNARNILYL   QMSGLRSEDT   AIYYCARRGD   PNMITTLFGY   WGQGTLVTIS
AAKTTPPSVT   SGQAGQHHHH   HHGAYPYDVP   DYAS
```

SEQ ID NO:93 (a fusion of **SEQ ID NOs:44, 87 and 45**):

```
IQEEFKMKKT   AIAIAVALAG   FATVAQAADV   LMTQTPLSLP   VSLGDQASIS
CRSSQSILHR   NGNTYLDWFL   LKPGQSPKLL   IYKVSNRFSG   VPDRFSGSGS
GTDFTLKISR   VEAEDLGVYY   CFQGSHVPWT   FGGGTKLEIK   ssggggsggg
gggssrssEV   KLVESGGGLV   KPGGSLTLSC   AASGFTFSSY   AMSWVRQTPE
KSLEWVASIS   SGGNTFYPDT   VKGRFTISRD   NARNILYLQM   SGLRSEDTAI
YYCARRGDPN   MITTLFGYWG   QGTLVTISAA   KTTPPSVTSG   QAGQ
```

SEQ ID NO:94 (a fusion of **SEQ ID NOs:44, 87 and 5**):

```
IQEEFKMKKT   AIAIAVALAG   FATVAQAADV   LMTQTPLSLP   VSLGDQASIS
CRSSQSILHR   NGNTYLDWFL   LKPGQSPKLL   IYKVSNRFSG   VPDRFSGSGS
GTDFTLKISR   VEAEDLGVYY   CFQGSHVPWT   FGGGTKLEIK   ssggggsggg
gggssrssEV   KLVESGGGLV   KPGGSLTLSC   AASGFTFSSY   AMSWVRQTPE
KSLEWVASIS   SGGNTFYPDT   VKGRFTISRD   NARNILYLQM   SGLRSEDTAI
YYCARRGDPN   MITTLFGYWG   QGTLVTISAH   HHHH
```

SEQ ID NO:95 (a fusion of **SEQ ID NOs:44, 87 and 6**):

```
IQEEFKMKKT   AIAIAVALAG   FATVAQAADV   LMTQTPLSLP   VSLGDQASIS
CRSSQSILHR   NGNTYLDWFL   LKPGQSPKLL   IYKVSNRFSG   VPDRFSGSGS
GTDFTLKISR   VEAEDLGVYY   CFQGSHVPWT   FGGGTKLEIK   ssggggsggg
gggssrssEV   KLVESGGGLV   KPGGSLTLSC   AASGFTFSSY   AMSWVRQTPE
KSLEWVASIS   SGGNTFYPDT   VKGRFTISRD   NARNILYLQM   SGLRSEDTAI
YYCARRGDPN   MITTLFGYWG   QGTLVTISAG   AYPYDVPDYA   S
```

SEQ ID NO:96 (a fusion of **SEQ ID NOs:44, 87 and 46**):

```
IQEEFKMKKT   AIAIAVALAG   FATVAQAADV   LMTQTPLSLP   VSLGDQASIS
CRSSQSILHR   NGNTYLDWFL   LKPGQSPKLL   IYKVSNRFSG   VPDRFSGSGS
GTDFTLKISR   VEAEDLGVYY   CFQGSHVPWT   FGGGTKLEIK   ssggggsggg
gggssrssEV   KLVESGGGLV   KPGGSLTLSC   AASGFTFSSY   AMSWVRQTPE
KSLEWVASIS   SGGNTFYPDT   VKGRFTISRD   NARNILYLQM   SGLRSEDTAI
YYCARRGDPN   MITTLFGYWG   QGTLVTISAA   KTTPPSVTSG   QAGQHHHHHH
GAYPYDVPDY   AS
```

[00134]   Although scFv are able to transit across the blood-brain barrier, various ancillary
approaches may be used to further promote such transit (Huang, L. *et al.* (2013) "*Single-*

Chain Fragment Variable Passive Immunotherapies For Neurodegenerative Diseases," Int. J. Mol. Sci. 14(9):19109-19127). A limited set of proteins and peptides are transported across the blood-brain barrier via receptor-mediated transcytosis (Hervé, F. *et al.* (2008) "*CNS Delivery Via Adsorptive Transcytosis,*" AAPS J. 10(3):455-472), the three best-studied ligands being insulin, iron-transferrin and LDL-cholesterol (Bickel, U. *et al.* (2001) "*Delivery Of Peptides And Proteins Through The Blood-Brain Barrier,*" Adv. Drug Deliv. Rev. 46:247-279; Tuma, P.L. *et al.* (2003) "*Transcytosis: Crossing Cellular Barriers,*" Physiol. Rev. 83:871-932). Thus, transport of an scFv across the blood-brain barrier can be promoted by fusing the scFv to an antibody, or an epitope-binding fragment thereof, that is immunospecific for a receptor of such ligands (*e.g.*, the human insulin receptor (HIR), the transferrin receptor (TfR), low density lipoprotein receptor-related proteins 1 (LRP1) and 2 (LRP2), non-toxic diphtheria toxin receptor/ Heparin binding epidermal growth factor-like growth factor, *etc*). The resulting fusion protein can be transported across the blood-brain barrier through its binding to the receptor (Boado, R.J. *et al.* (2010) "*IgG-Single-Chain Fv Fusion Protein Therapeutic For Alzheimer's Disease: Expression In CHO cells And Pharmacokinetics And Brain Delivery In The Rhesus Monkey,*" Biotechnol. Bioeng. 105:627–635; Jones, A.R. *et al.* (2007) "*Blood-Brain Barrier Transport Of Therapeutics Via Receptor-Mediation,*" Pharm. Res. 24(9):1759-1771; Wang, Y.Y. *et al.* (2009) "*Receptor-Mediated Therapeutic Transport Across The Blood-Brain Barrier,*" Immunotherapy 1(6):983-993; Lajoie, J.M. *et al.* (2015) "*Targeting Receptor-Mediated Transport For Delivery Of Biologics Across The Blood-Brain Barrier,*" Annu. Rev. Pharmacol. Toxicol. 55:613-631; Pardridge, W.M. (2102) "*Drug Transport Across The Blood-Brain Barrier,*" J. Cereb. Blood Flow Metab. 32(11):1959-1972; Bhaskar, S. *et al.* (2010) "*Multifunctional Nanocarriers For Diagnostics, Drug Delivery And Targeted Treatment Across Blood-Brain Barrier: Perspectives On Tracking And Neuroimaging,*" Part. Fibre. Toxicol. 7:3 pp. 1-25).

[00135]   The scFv may be augmented to contain a polycationic peptide that facilitates adsorptive-mediated transcytosis. Suitable polycationic peptides include hexamethylene-diamine, putrescine, spermidine and spermine (Hervé, F. *et al.* (2008) "*CNS Delivery Via Adsorptive Transcytosis,*" AAPS J. 10(3):455-472; Kandimalla, K.K. *et al.* (2006) "*Physiological And Biophysical Factors That Influence Alzheimer's Disease Amyloid Plaque Targeting Of Native And Putrescine Modified Human Amyloid Beta40,*" J. Pharmacol. Exp. Ther. 318:17-25). The scFv may be augmented to comprise polycationic groups via

treatment that amidates some or all of its carboxylic groups (*i.e.*, the carboxy-terminal group, or the carboxylic side chains of glutamate or aspartate residue(s) of the scFv).

[00136]   Alternatively, the scFv may be augmented to contain a cell-penetrating peptide ("CPP") (Rao, K.S. *et al.* (2009) "*Targeting Anti-HIV Drugs To The CNS,*" Expert Opin. Drug Deliv. 6(8):771-784; Mathupala, S.P. *et al.* (2009) "*Delivery Of Small-Interfering RNA (siRNA) To The Brain,*" Expert Opin. Ther. Pat. 19(2):137-140; Hervé, F. *et al.* (2008) "*CNS Delivery Via Adsorptive Transcytosis,*" AAPS J. 10(3):455-472). Such peptides include the HIV-1 trans-activating transcriptional activator (TAT) peptide, the Herpes Simplex Virus type-1 transcription factor (HSV VP-22) peptide, antennapedia and penetratin (Wadia, J.S. *et al.* (2004) "*Transducible TAT-HA Fusogenic Peptide Enhances Escape Of TAT-Fusion Proteins After Lipid Raft Macropinocytosis,*" Nat. Med. 10:310-315; Richard, J.P. *et al.* (2003) "*Cell-Penetrating Peptides. A Reevaluation Of The Mechanism Of Cellular Uptake,*" J. Biol. Chem. 278:585-590; Temsamani, J. *et al.* (2004) "*The Use Of Cell-Penetrating Peptides For Drug Delivery,*" Drug Discov. Today 9:1012-1019).

C.   Consensus CDR Sequences

[00137]   Analyses of the CDRs of the identified antibodies were conducted in order to identify consensus CDR sequences and likely variant CDR sequences that would provide binding attributes similar to those of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 and/or Antibody 5G2A3. Such variant CDRs were computed using Blosum62.iij analysis according to **Table 1**. **Table 1** presents the Blosum62.iij substitution scores. The higher the score the more conservative the substitution and thus the more likely the substitution will not affect function.

[00138]   The present invention permits the formation of novel antibodies and antigen-binding fragments having 1, 2, 3, 4, 5 or 6 variant CDRs. Because the methods of the present invention have identified a substantial number of distinct CDRs, the invention permits a recognition of CDR residues that are likely to be required in any variant of a particular identified CDR. Such residues are shown in boldface in **Table 5** and **Table 6**. For those residues that are found to vary among the compared CDRs, the substitution scores of **Table 1** provide a means for determining the identities of likely substitutions. For example, if a particular residue of a particular CDR is found to vary as R or S, then since R and S have a substitution score of -1, any substitution for R or S having a substitution score of -1 or greater are as likely as the observed variants (R or S) (or are more likely than R or S) to create a

variant CDR having binding attributes that are sufficiently similar to those of the particular CDR to permit the variant CDR to be employed in lieu thereof so as to form a functional antibody or antigen-binding fragment. For each position, the selection of a residue having a higher substitution score is preferred over the selection of a residue having a lower substitution score.

[00139]   Table 5 presents an analysis of the light chain CDRs of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 and Antibody 5G2A3 and provides the consensus sequence of the observed light chain CDRs of the disclosed antibodies of the present invention.

Table 5: Light Chain Consensus CDRs			
Light Chain CDR1			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		RSS QSILN S NGNTYLE	**9**
1G11A10		RSS QSIIN S NGNTYLE	**17**
5B3C11	1	RSN QSILH S NGNTYLD	**25**
5G2A3		RSS QSILH R NGNTYLD	**37**
Light Chain CDR1 Consensus Sequence:		RSX$_1$QSILX$_2$X$_3$NGNTYLX$_4$	**97**
X_1 are substitutions of N/S or substitutions having an equal or greater substitution score (*i.e.*, ≥ +1): N or S X_2 are substitutions of N/H or substitutions having an equal or greater substitution score (*i.e.*, ≥ +1): N or H X_3 are substitutions of S/R, or substitutions having an equal or greater substitution score (*i.e.*, ≥ -1): A, R, N, Q, E, H, K, M, S, or T X_4 are substitutions of E/D or substitutions having an equal or greater substitution score (*i.e.*, ≥ +2): E or D			
Light Chain CDR2			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		KVSNRFS	**10**
1G11A10		KVSNRFS	**18**
5B3C11	1	KVSNRFS	**26**
5G2A3		KVSNRFS	**38**
Light Chain CDR2 Consensus Sequence:		KVSNRFS	**98**
Light Chain CDR3			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		FQGSHV PWT	**11**
1G11A10		FQGSHV PWT	**19**
5B3C11	1	FQGSHI PWT	**27**
5G2A3		FQGSHV PWT	**39**
Light Chain CDR3 Consensus Sequence:		FQGSHX$_1$PWT	**99**
X_1 are substitutions of V/I or substitutions having an equal or greater substitution score (*i.e.*, ≥ +3): V or I			

[00140]   Table 6 presents an analysis of the heavy chain CDRs of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 and Antibody 5G2A3 and provides the consensus sequence of the observed heavy chain CDRs of the disclosed antibodies of the present invention.

Table 6: Heavy Chain Consensus CDRs			
Heavy Chain CDR1			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		D S AM S	13
1G11A10		S Y AM S	21
5B3C11	1	N Y AL S	33
5G2A3		S Y AM S	41
Heavy Chain CDR1 Consensus Sequence:		$X_1X_2AX_3S$	100

X_1 are substitutions of D/N/S or substitutions having an equal or greater substitution score (*i.e.*, ≥ 0): N, D, Q, E or S

X_2 are substitutions of S/Y or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, N, D, C, Q, E, G, H, I, L, K, M, F, S, T, Y or V

X_3 are substitutions of L/M, or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ +2): L or M

Heavy Chain CDR2			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		SIST GGA TY Y PDG L KG	14
1G11A10		SISS GGQ TY S PDS V KG	22
5B3C11	1	SISS GGN TY Y PDS V KG	34
5G2A3		SISS GGN TF Y PDT V KG	42
Heavy Chain CDR2 Consensus Sequence:		$SISX_1GGX_2TX_3X_4PDX_5X_6KG$	101

X_1 are substitutions of S/T or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ +1): S or T

X_2 are substitutions of A/Q/N or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, N, D, Q, E, G, H, K, M, P, S, T or Y

X_3 are substitutions of F/Y or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ +3): F or Y

X_4 are substitutions of S/Y or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, N, C, Q, E, H, I, L, K, M, F, S, T, Y or V

X_5 are substitutions of G/S/T or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, N, D, Q, E, G, H, I, L, K, P, S or T

X_6 are substitutions of L/V or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ +1): I, L, M or V

Heavy Chain CDR3			
Antibody	**Variant**	**Sequence**	**SEQ ID NO**
1G10D2		RG V S S G N LFT Y	15
1G11A10		RGD P T M T A T LFV Y	23
5B3C11		RGD T T L I T T LFT Y	35
5G2A3		RGD P N M I T T LFG Y	43
Heavy Chain CDR3 Consensus Sequence:		$RGX_1X_2X_3X_4X_5X_6X_7LFX_8Y$	102

X_1 is absent or D

X_2 is absent or are substitutions of P/T or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -1): A, D, Q, E, K, P, S or T

X_3 are substitutions of V/T/N or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -3): A, R, N, D, C, Q, E, G, H, I, L, K, M, F, P, S, T, Y or V

X_4 are substitutions of S/L/M or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, C, I, L, K, M, F, S, T, Y or V

X_5 are substitutions of S/T/I or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, C, I, L, M, F, S, T, Y or V

X_6 are substitutions of G/A/T or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -2): A, R, N, D, Q, E, G, H, I, L, K, P, S or T

X_7 are substitutions of N/T or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ 0): N, S or T

X_8 are substitutions of T/V/G or substitutions having an equal or greater substitution score (*i.e.*, $\geq$ -3): A ,R ,N, D, C, Q, E, G, H, K, M, F, P, S, T, W, Y or V

[00141]   Thus, in addition to antibodies and antigen-binding fragments thereof that possess the CDRs of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3, the invention additionally provides antibodies and antigen-binding fragments thereof that possess CDRs having amino acid sequences deduced from such light and/or heavy chain consensus CDR sequences.

[00142]   Although scFv are able to transit across the blood-brain barrier, various ancillary approaches may be used to further promote such transit (Huang, L. *et al.* (2013) *"Single-Chain Fragment Variable Passive Immunotherapies For Neurodegenerative Diseases,"* Int. J. Mol. Sci. 14(9):19109-19127). A limited set of proteins and peptides are transported across the blood-brain barrier via receptor-mediated transcytosis (Hervé, F. *et al.* (2008) *"CNS Delivery Via Adsorptive Transcytosis,"* AAPS J. 10(3):455-472), the three best-studied ligands being insulin, iron-transferrin and LDL-cholesterol (Bickel, U. *et al.* (2001) *"Delivery Of Peptides And Proteins Through The Blood-Brain Barrier,"* Adv. Drug Deliv. Rev. 46:247-279; Tuma, P.L. *et al.* (2003) *"Transcytosis: Crossing Cellular Barriers,"* Physiol. Rev. 83:871-932). Thus, transport of an scFv across the blood-brain barrier can be promoted by fusing the scFv to an antibody, or an epitope-binding fragment thereof, that is immunospecific for a receptor of such ligands (*e.g.,* the human insulin receptor (HIR), the transferrin receptor (TfR), low density lipoprotein receptor-related proteins 1 (LRP1) and 2 (LRP2), non-toxic diphtheria toxin receptor/ Heparin binding epidermal growth factor-like growth factor, *etc*). The resulting fusion protein can be transported across the blood-brain barrier through its binding to the receptor (Boado, R.J. *et al.* (2010) *"IgG-Single-Chain Fv Fusion Protein Therapeutic For Alzheimer's Disease: Expression In CHO cells And Pharmacokinetics And Brain Delivery In The Rhesus Monkey,"* Biotechnol. Bioeng. 105:627–635; Jones, A.R. *et al.* (2007) *"Blood-Brain Barrier Transport Of Therapeutics Via Receptor-Mediation,"* Pharm. Res. 24(9):1759-1771; Wang, Y.Y. *et al.* (2009) *"Receptor-Mediated Therapeutic Transport Across The Blood-Brain Barrier,"* Immunotherapy 1(6):983-993; Lajoie, J.M. *et al.* (2015) *"Targeting Receptor-Mediated Transport For Delivery Of Biologics Across The Blood-Brain Barrier,"* Annu. Rev. Pharmacol. Toxicol. 55:613-631; Pardridge, W.M. (2102) *"Drug Transport Across The Blood-Brain Barrier,"* J. Cereb. Blood Flow Metab. 32(11):1959-1972; Bhaskar, S. *et al.* (2010) *"Multifunctional Nanocarriers For Diagnostics, Drug Delivery And Targeted Treatment Across Blood-Brain Barrier: Perspectives On Tracking And Neuroimaging,"* Part. Fibre. Toxicol. 7:3 pp. 1-25).

[00143]   The scFv may be augmented to contain a polycationic peptide that facilitates adsorptive-mediated transcytosis. Suitable polycationic peptides include hexamethylene-diamine, putrescine, spermidine and spermine (Hervé, F. *et al.* (2008) *"CNS Delivery Via Adsorptive Transcytosis,"* AAPS J. 10(3):455-472; Kandimalla, K.K. *et al.* (2006) *"Physiological And Biophysical Factors That Influence Alzheimer's Disease Amyloid Plaque Targeting Of Native And Putrescine Modified Human Amyloid Beta40,"* J. Pharmacol. Exp. Ther. 318:17-25).   The scFv may be augmented to comprise polycationic groups via treatment that amidates some or all of its carboxylic groups (*i.e.,* the carboxy-terminal group, or the carboxylic side chains of glutamate or aspartate residue(s) of the scFv).

[00144]   Alternatively, the scFv may be augmented to contain a cell-penetrating peptide ("CPP") (Rao, K.S. *et al.* (2009) *"Targeting Anti-HIV Drugs To The CNS,"* Expert Opin. Drug Deliv. 6(8):771-784; Mathupala, S.P. *et al.* (2009) *"Delivery Of Small-Interfering RNA (siRNA) To The Brain,"* Expert Opin. Ther. Pat. 19(2):137-140; Hervé, F. *et al.* (2008) *"CNS Delivery Via Adsorptive Transcytosis,"* AAPS J. 10(3):455-472).   Such peptides include the HIV-1 trans-activating transcriptional activator (TAT) peptide, the Herpes Simplex Virus type-1 transcription factor (HSV VP-22) peptide, antennapedia and penetratin (Wadia, J.S. *et al.* (2004) *"Transducible TAT-HA Fusogenic Peptide Enhances Escape Of TAT-Fusion Proteins After Lipid Raft Macropinocytosis,"* Nat. Med. 10:310-315; Richard, J.P. *et al.* (2003) *"Cell-Penetrating Peptides. A Reevaluation Of The Mechanism Of Cellular Uptake,"* J. Biol. Chem. 278:585-590; Temsamani, J. *et al.* (2004) *"The Use Of Cell-Penetrating Peptides For Drug Delivery,"* Drug Discov. Today 9:1012-1019).

III.   Uses of the Antibodies and Antibody Fragments of the Present Invention

[00145]   The present invention relates to the use of antibody-based molecules that are immunospecific for the Asp421 Epitope to diagnose and/or treat Alzheimer's disease or tauopathy in a subject patient. With respect to such diagnostic utility, such uses may involve detecting, in the subject (*i.e., in vivo*), the presence of a pathological Tau conformer using, for example, Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3, or an Asp421 Epitope-binding fragment thereof (and especially an scFv fragment thereof), that has preferably been detectably labeled (such molecules being collectively referred to herein as the diagnostic molecules of the present invention). Alternatively, such uses may involve detecting the presence of a pathological Tau conformer *ex vivo* (*e.g.,* in a biopsy sample, or post-mortem) using the diagnostic molecules of the present invention.

[00146]   In one embodiment, the Asp421 Epitope-specific antibody-based molecules of the present invention may be humanized antibodies.

[00147]   With respect to the therapeutic utility of the Asp421 Epitope-specific antibody-based molecules of the present invention, such utility may involve the administration of a therapeutically effective amount of such an antibody-based molecule (*e.g.*, Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 or Antibody 5G2G6, and more particularly, an scFv fragment thereof) to a patient having one or more symptoms of Alzheimer's disease or such tauopathy, and thus in need of such therapy, or it may involve the administration of a prophylactically effective amount of such antibody-based molecules to a patient not exhibiting such symptoms, or exhibiting symptoms of mild dementia or pre-tauopathy that is indicative of incipient Alzheimer's disease or tauopathy, such molecules being collectively referred to herein as the therapeutic molecules of the present invention.

[00148]   The Asp421 Epitope-specific antibody-based molecules of the present invention may be used in concert for diagnostic and/or therapeutic purposes with antibodies and antibody-based molecules having immunospecificity for epitopes other than the Asp421 Epitope.

IV.   Production of the Tau-Binding Molecules of the Present Invention

[00149]   The Tau-binding molecules of the present invention are preferably produced via the recombinant expression of a nucleic acid molecule that encodes their constituent polypeptide chain(s). The invention thus accordingly also relates to an expression vector encoding such one or more polypeptide chains of an antibody of the invention or a fragment thereof.

[00150]   An expression vector in the context of the present invention may be any suitable DNA or RNA vector, including chromosomal, non-chromosomal, and synthetic nucleic acid vectors (a nucleic acid sequence comprising a suitable set of expression control elements). Examples of such vectors include derivatives of SV40, bacterial plasmids, phage DNA, baculovirus, yeast plasmids, vectors derived from combinations of plasmids and phage DNA, and viral nucleic acid (RNA or DNA) vectors. In one embodiment, an anti-Tau antibody-encoding nucleic acid is comprised in a naked DNA or RNA vector, including, for example, a linear expression element (as described in, for instance, Sykes and Johnston, Nat Biotech 12, 355-59 (1997)), a compacted nucleic acid vector (as described in for instance US 6,077,835

and/or WO 00/70087), a plasmid vector such as pBR322, pUC 19/18, or pUC 118/119, a "midge" minimally-sized nucleic acid vector (as described in, for instance, Schakowski et al., Mol Ther 3, 793-800 (2001)), or as a precipitated nucleic acid vector construct, such as a CaP04-precipitated construct (as described in, for instance, WO 00/46147, Benvenisty and Reshef, PNAS USA 83, 9551-55 (1986), Wigler et al., Cell 14, 725 (1978), and Coraro and Pearson, Somatic Cell Genetics 2, 603 (1981)). Such nucleic acid vectors and the usage thereof are well-known in the art (see for instance US 5,589,466 and US 5,973,972).

[00151]   In one embodiment, the vector is suitable for the expression of an Asp421 Epitope-specific antibody-based molecule of the present invention in a bacterial cell. Examples of such vectors include expression vectors such as BlueScript (Stratagene), pIN vectors (Van Heeke & Schuster, J Biol Chem 264, 5503-5509 (1989), pET vectors (Novagen, Madison, WI) and the like). An expression vector may also or alternatively be a vector suitable for expression of such antibody-based molecules in a yeast system. Any vector suitable for expression in a yeast system may be employed. Suitable vectors include, for example, vectors comprising constitutive or inducible promoters such as alpha factor, alcohol oxidase and PGH (reviewed in: F. Ausubel et al., ed. CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, Greene Publishing and Wiley InterScience New York (1987), and Grant et al., Methods in Enzymol 153, 516-544 (1987)).

[00152]   In an expression vector of the invention, a nucleic acid molecule encoding an Asp421 Epitope-specific antibody-based molecule of the present invention may comprise or be associated with any suitable promoter, enhancer, and other expression-facilitating elements. Examples of such elements include strong expression promoters (*e.g.*, human CMV IE promoter/enhancer as well as RSV, SV40, SL3-3, MMTV, and HIV LTR promoters), effective poly (A) termination sequences, an origin of replication for plasmid product in E. coli, an antibiotic resistance gene as selectable marker, and/or a convenient cloning site (*e.g.*, a polylinker). Nucleic acids may also comprise an inducible promoter as opposed to a constitutive promoter such as CMV IE (the skilled artisan will recognize that such terms are actually descriptors of a degree of gene expression under certain conditions).

[00153]   In an even further aspect, the invention relates to a recombinant eukaryotic or prokaryotic host cell, such as a transfectoma, that produces an Asp421 Epitope-specific antibody-based molecule of the present invention. Examples of host cells include yeast, bacteria, and mammalian cells, such as CHO or HEK cells. For example, in one

embodiment, the present invention provides a cell comprising a nucleic acid stably integrated into the cellular genome that comprises a sequence coding for expression of an Asp421 Epitope-specific antibody-based molecule of the present invention. In another embodiment, the present invention provides a cell comprising a non-integrated nucleic acid, such as a plasmid, cosmid, phagemid, or linear expression element, that which comprises a sequence coding for expression of an Asp421 Epitope-specific antibody-based molecule of the present invention.

[00154] In a further aspect, the invention relates to a method for producing an Asp421 Epitope-specific antibody-based molecule of the present invention, said method comprising the steps of a) culturing a hybridoma or a host cell of the invention as described herein above, and b) purifying the antibody of the invention from the culture media.

[00155] In general, an Asp421 Epitope-specific antibody-based molecule of the present invention may be modified by inclusion of any suitable number of modified amino acids and/or associations with such conjugated substituents. Suitability in this context is generally determined by the ability to at least substantially retain the immunospecificity for the Asp421 Epitope associated with the non-derivatized parent anti-Tau antibody. The presence of one or more modified amino acids may be advantageous in, for example, increasing polypeptide serum half-life, reducing polypeptide antigenicity, or increasing polypeptide storage stability. Amino acid(s) are modified, for example, co-translationally or post-translationally during recombinant production (*e.g.*, N-linked glycosylation at N-X-S/T motifs during expression in mammalian cells) or modified by synthetic means. Non-limiting examples of a modified amino acid include a glycosylated amino acid, a sulfated amino acid, a prenylated (*e.g.*, farnesylated, geranylgeranylated) amino acid, an acetylated amino acid, an acylated amino acid, a PEGylated amino acid, a biotinylated amino acid, a carboxylated amino acid, a phosphorylated amino acid, and the like. References adequate to guide one of skill in the modification of amino acids are replete throughout the literature. Example protocols are found in Walker (1998) *Protein Protocols On CD-Rom*, Humana Press, Totowa, NJ. The modified amino acid may, for instance, be selected from a glycosylated amino acid, a PEGylated amino acid, a farnesylated amino acid, an acetylated amino acid, a biotinylated amino acid, an amino acid conjugated to a lipid moiety, or an amino acid conjugated to an organic derivatizing agent.

[00156] As indicated above, when it is desired to increase the half-life of an administered therapeutic molecule of the present invention, such molecules may be formed to comprise carbohydrate moieties, such as polyoxyethylated polyols or polyethylene glycol (PEG) (*e.g.*, a PEG with a molecular weight of between about 1,000 and about 40,000, such as between about 2,000 and about 20,000, *e.g.*, about 3,000-12,000 g/mol) (Moosmann, A. *et al.* (2014) "*Purification Of PEGylated Proteins, With The Example Of PEGylated Lysozyme and PEGylated scFv,*" Methods Mol. Biol. 1129:527-538; Jevsevar, S. *et al.* (2010) "*PEGylation Of Therapeutic Proteins,*" Biotechnol. J. 5:113-228), or through glycosylation or by adding or associating proteins such as human serum albumin (Müller, M.R. *et al.* (2012) "*Improving The Pharmacokinetic Properties Of Biologics By Fusion To An Anti-HSA Shark VNAR Domain,*" MAbs. 4(6):673-685; Stork, R. *et al.* (2008) "*N-Glycosylation As Novel Strategy To Improve Pharmacokinetic Properties Of Bispecific Single-Chain Diabodies,*" J. Biol. Chem. 283:7804-7812; Alt, M. *et al.* (1999) "*Novel Tetravalent And Bispecific IgG-like Antibody Molecules Combining Single-Chain Diabodies With The Immunoglobulin Gamma1 Fc or CH3 Region,*" FEBS Lett. 454:90-94; Peters T. *et al.* (1985) "*Serum Albumin,*" Adv. Protein Chem. 37:161-245). Illustrative polymers and methods to attach them to peptides, are known, (see, for example, US Patents No. 4,766,106; 4,179,337; 4,495,285 and 4,609,546).

V.   Pharmaceutical Compositions of the Present Invention

[00157] The Asp421 Epitope-specific antibody-based molecules of the present invention are advantageously administered as pharmaceutical compositions comprising an active therapeutic agent and one or more of a variety of other pharmaceutically acceptable components. See REMINGTON: THE SCIENCE AND PRACTICE OF PHARMACY (21st Edition) (2005) (Troy, D.B. *et al.* (Eds.) Lippincott Williams & Wilkins (Publs.), Baltimore MD), which is hereby incorporated by reference in its entirety. The preferred form depends on the intended mode of administration and therapeutic application. The compositions can also include, depending on the formulation desired, pharmaceutically acceptable, non-toxic carriers, excipients, diluents, fillers, salts, buffers, detergents (e.g., a nonionic detergent, such as Tween-20 or Tween- 80), stabilizers (e.g., sugars or protein-free amino acids), preservatives, tissue fixatives, solubilizers, and/or other materials suitable for inclusion in a pharmaceutical composition, and which are vehicles commonly used to formulate pharmaceutical compositions for animal or human administration. The diluent is selected to not to affect the biological activity of the combination. Examples of such diluents are distilled water, physiological phosphate-buffered saline, Ringer's solutions, dextrose solution, and

Hank's solution. In addition, the pharmaceutical composition or formulation may also include other carriers, or non-toxic, nontherapeutic, non-immunogenic stabilizers and the like. Examples of suitable aqueous and non-aqueous carriers which may be employed in the pharmaceutical compositions of the present invention include water, saline, phosphate-buffered saline, ethanol, dextrose, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures thereof, vegetable oils, such as olive oil, corn oil, peanut oil, cottonseed oil, and sesame oil, carboxymethyl cellulose colloidal solutions, tragacanth gum and injectable organic esters, such as ethyl oleate, and/or various buffers. Other carriers are well-known in the pharmaceutical arts.

[00158] Pharmaceutically acceptable carriers include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. The use of such media and agents for pharmaceutically active substances is known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the pharmaceutical compositions of the present invention is contemplated.

[00159] The compositions may also include large, slowly metabolized macromolecules, such as proteins, polysaccharides like chitosan, polylactic acids, polyglycolic acids and copolymers (e.g., latex functionalized sepharose, agarose, cellulose, and the like), polymeric amino acids, amino acid copolymers, and lipid aggregates (e.g., oil droplets or liposomes). Suitability for carriers and other components of pharmaceutical compositions is determined based on the lack of significant negative impact on the desired biological properties of the chosen compound or pharmaceutical composition of the present invention (e.g., less than a substantial impact (*e.g.*, 10% or less relative inhibition, 5% or less relative inhibition, *etc.*)) on antigen binding.

[00160] The pharmaceutical compositions of the present invention may also comprise pharmaceutically acceptable antioxidants for instance (1) water soluble antioxidants, such as ascorbic acid, cysteine hydrochloride, sodium bisulfate, sodium metabisulfite, sodium sulfite and the like; (2) oil-soluble antioxidants, such as ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), lecithin, propyl gallate, alpha-tocopherol, and the like; and (3) metal chelating agents, such as citric acid, ethylenediamine tetraacetic acid (EDTA), sorbitol, tartaric acid, phosphoric acid, and the like.

[00161] The pharmaceutical compositions of the present invention may also comprise isotonicity agents, such as sugars, polyalcohols, such as mannitol, sorbitol, glycerol or sodium chloride in the compositions.

[00162] The pharmaceutical compositions of the present invention may also contain one or more adjuvants appropriate for the chosen route of administration such as preservatives, wetting agents, emulsifying agents, dispersing agents, preservatives or buffers, which may enhance the shelf life or effectiveness of the pharmaceutical composition. The compounds of the present invention may be prepared with carriers that will protect the compound against rapid release, such as a controlled release formulation, including implants, transdermal patches, and microencapsulated delivery systems. Such carriers may include gelatin, glyceryl monostearate, glyceryl distearate, biodegradable, biocompatible polymers such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid alone or with a wax, or other materials well-known in the art. Methods for the preparation of such formulations are generally known to those skilled in the art. See, e.g., SUSTAINED AND CONTROLLED RELEASE DRUG DELIVERY SYSTEMS, J. R. Robinson, ed., Marcel Dekker, Inc., New York, 1978.

[00163] In one embodiment, the compounds of the present invention may be formulated to ensure proper distribution *in vivo*. Pharmaceutically acceptable carriers for parenteral administration include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. The use of such media and agents for pharmaceutically active substances is known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the pharmaceutical compositions of the present invention is contemplated. Supplementary active compounds may also be incorporated into the compositions.

[00164] Pharmaceutical compositions for injection must typically be sterile and stable under the conditions of manufacture and storage. The composition may be formulated as a solution, microemulsion, liposome, or other ordered structure suitable to high drug concentration. The carrier may be an aqueous or non-aqueous solvent or dispersion medium containing for instance water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures thereof, vegetable oils, such as olive oil, and injectable organic esters, such as ethyl oleate. The proper fluidity may be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the

required particle size in the case of dispersion and by the use of surfactants. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as glycerol, mannitol, sorbitol, or sodium chloride in the composition. Prolonged absorption of the injectable compositions may be brought about by including in the composition an agent that delays absorption, for example, monostearate salts and gelatin. Sterile injectable solutions may be prepared by incorporating the active compound in the required amount in an appropriate solvent with one or a combination of ingredients e.g. as enumerated above, as required, followed by sterilization microfiltration. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients e.g. from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, examples of methods of preparation are vacuum drying and freeze-drying (lyophilization) that yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

[00165] Sterile injectable solutions may be prepared by incorporating the active compound in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by sterilization microfiltration. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, examples of methods of preparation are vacuum drying and freeze-drying (lyophilization) that yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

[00166]   For parenteral administration, agents of the present invention are typically formulated as injectable dosages of a solution or suspension of the substance in a physiologically acceptable diluent with a pharmaceutical carrier that can be a sterile liquid such as water, oil, saline, glycerol, or ethanol. Additionally, auxiliary substances, such as wetting or emulsifying agents, surfactants, pH buffering substances and the like can be present in compositions. Other components of pharmaceutical compositions are those of petroleum, animal, vegetable, or synthetic origin. Peanut oil, soybean oil, and mineral oil are all examples of useful materials. In general, glycols, such as propylene glycol or polyethylene glycol, are preferred liquid carriers, particularly for injectable solutions. Agents of the

invention can be administered in the form of a depot injection or implant preparation which can be formulated in such a manner as to permit a sustained release of the active ingredient. An exemplary composition comprises an scFv at about 5 mg/mL, formulated in aqueous buffer consisting of 50 mM L-histidine, 150 mM NaCl, adjusted to pH 6.0 with HCl.

[00167]   Typically, compositions are thus prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection can also be prepared. The preparation also can be emulsified or encapsulated in liposomes or micro particles, such as polylactide, polyglycolide, or copolymer, for enhanced adjuvant effect (Langer, *et al.*, Science 249:1527 (1990); Hanes, *et al.*, Advanced Drug Delivery Reviews 28:97-119 (1997), which are hereby incorporated by reference in their entirety). Additional formulations suitable for other modes of administration include oral, intranasal, and pulmonary formulations, suppositories, and transdermal applications.

VI.   Administration of the Pharmaceutical Compositions of the Present Invention

[00168]   The molecules of the present invention can be administered by parenteral, topical, oral or intranasal means for prophylactic and/or therapeutic treatment. Intramuscular injection (for example, into the arm or leg muscles) and intravenous infusion are preferred methods of administration of the molecules of the present invention. In some methods, such molecules are administered as a sustained release composition or device, such as a Medipad™ device (Elan Pharm. Technologies, Dublin, Ireland). In some methods, the molecules of the present invention are injected directly into a particular tissue where deposits have accumulated, for example intracranial injection.

[00169]   In one embodiment, a pharmaceutical composition of the present invention is administered parenterally. The phrases "parenteral administration" and "administered parenterally" as used herein denote modes of administration other than enteral and topical administration, usually by injection, and include epidermal, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intracranial, intraorbital, intracardiac, intradermal, intraperitoneal, intratendinous, transtracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal, intracranial, intrathoracic, epidural and intrasternal injection, subcutaneous and infusion. In one embodiment that pharmaceutical composition is administered by intravenous or subcutaneous injection or infusion.

[00170]   In prophylactic applications, pharmaceutical compositions or medicaments are administered to a patient susceptible to, or otherwise at risk of, Alzheimer's disease in an amount sufficient to eliminate or reduce the risk, lessen the severity, or delay the outset of the disease, including biochemical, histologic and/or behavioral symptoms of the disease, its complications and intermediate pathological phenotypes presented during development of the disease.

[00171]   In therapeutic applications (*i.e.*, in applications involving a patient who has been diagnosed as having Alzheimer's disease or other tauopathy) the therapeutic molecules of the present invention are administered to such patient in an amount sufficient to cure, treat, or at least partially arrest, the symptoms of the disease (as adduced by biochemical, histologic and/or behavioral assessment), including its complications and intermediate pathological phenotypes in development of the disease. In some embodiments, the administration of the therapeutic molecules of the present invention reduces or eliminates mild cognitive impairment in patients that have not yet developed characteristic Alzheimer's pathology.

[00172]   Effective doses of the provided therapeutic molecules of the present invention, for the treatment of the above-described conditions may vary depending upon many different factors, including means of administration, target site, physiological state of the patient, other medications administered, and whether treatment is prophylactic or therapeutic. Treatment dosages are typically titrated to optimize their safety and efficacy. On any given day that a dosage is given, the dosage may range from about 0.0001 to about 100 mg/kg, and more usually from about 0.01 to about 10 mg/kg, of the host body weight. For example, dosages can be 1 mg/kg body weight or 10 mg/kg body weight or within the range of 1-10 mg/kg body weight. Exemplary dosages thus include: from about 0.1 to about 10 mg/kg/body weight, from about 0.1 to about 5 mg/kg/body weight, from about 0.1 to about 2 mg/kg/body weight, from about 0.1 to about 1 mg/kg/body weight, for instance about 0.15 mg/kg/body weight, about 0.2 mg/kg/body weight, about 0.5 mg/kg/body weight, about 1 mg/kg/body weight, about 1.5 mg/kg/body weight, about 2 mg/kg/body weight, about 5 mg/kg/body weight, or about 10 mg/kg/body weight

[00173]   A physician or veterinarian having ordinary skill in the art may readily determine and prescribe the effective amount of the pharmaceutical composition required. For example, the physician or veterinarian could start doses of the anti-Tau antibody or fragment employed in the pharmaceutical composition at levels lower than that required in order to achieve the

desired therapeutic effect and gradually increase the dosage until the desired effect is achieved. In general, a suitable daily dose of a composition of the present invention will be that amount of the compound which is the lowest dose effective to produce a therapeutic effect. Such an effective dose will generally depend upon the factors described above. Administration may e.g. be intravenous, intramuscular, intraperitoneal, or subcutaneous, and for instance administered proximal to the site of the target. If desired, the effective daily dose of a pharmaceutical composition may be administered as two, three, four, five, six or more sub-doses administered separately at appropriate intervals throughout the day, optionally, in unit dosage forms. While it is possible for a compound of the present invention to be administered alone, it is preferable to administer the compound as a pharmaceutical composition as described above.

[00174]   An exemplary treatment regime entails administration once per every two weeks or once a month or once every 3 to 6 months. In some methods, one, two or more antibodies (or epitope-binding fragments thereof) will be administered in conjunction with the administration of the therapeutic molecules of the present invention, in which case the dosage of each such administered molecule falls within the ranges indicated.

[00175]   The dosage and frequency of administration can vary depending on whether the treatment is prophylactic or therapeutic. In prophylactic applications, a relatively low dosage is administered at relatively infrequent intervals over a long period of time. Some patients continue to receive treatment for the rest of their lives. In therapeutic applications, a relatively high dosage at relatively short intervals is sometimes required until progression of the disease is reduced or terminated, and preferably until the patient shows partial or complete amelioration of symptoms of disease. Thereafter, the patent can be administered such therapeutic molecule using a prophylactic dosage regime.

[00176]   For therapeutic purposes, the molecules of the present invention are usually administered on multiple occasions. Intervals between single dosages (e.g., a bolus or infusion) can be weekly, monthly, or yearly. In some methods, dosage is adjusted to achieve a plasma concentration of 1-1000 µg/mL and in some methods 25-300 µg/mL. Alternatively, the therapeutic molecules of the present invention can be administered as a sustained release formulation, in which case less frequent administration is required. Dosage and frequency vary depending on the half-life of the antibody in the patient. In general, human antibodies

show the longest half-life, followed by humanized antibodies, chimeric antibodies, and non-human antibodies. scFv molecules generally have short serum half-lives.

[00177] Another aspect of the present invention is a combination therapy wherein an additional antibody, or an epitope-binding fragment thereof, recognizing the Tau protein, or an immunogenic epitope thereof, is administered in combination with a therapeutic molecule of the present invention. In the case of amyloidogenic diseases such as, Alzheimer's disease and Down's syndrome, immune modulation to clear amyloid-beta (Aβ) deposits is an emerging therapy. Immunotherapies targeting Aβ have consistently resulted in cognitive improvements. It is likely that Tau and Aβ pathologies are synergistic. Therefore, a combination therapy targeting the clearance of both pathologies at the same time may be more effective than targeting each individually. In the case of Parkinson's Disease and related neurodegenerative diseases, immune modulation to clear aggregated forms of the α-synuclein protein is also an emerging therapy. A combination therapy which targets the clearance of both Tau and α-synuclein proteins simultaneously may be more effective than targeting each individually.

VII.   Utility of the Tau-Binding Molecules of the Present Invention

A.   Diagnostic Utility

[00178] Detecting the presence of a pathological Tau conformer in a subject using an Asp421 Epitope-specific antibody-based diagnostic molecule of the present invention can be achieved by obtaining a biological sample from the subject (*e.g.*, blood, urine, cerebral spinal fluid), contacting the biological sample with said diagnostic antibody, and detecting binding of the diagnostic molecule to a pathological Tau protein conformer in the sample from the subject. Assays for carrying out the detection of a pathological Tau protein in a biological sample that may be readily adapted to the detection of the diagnostic molecules of the present invention are well-known in the art and include, without limitation, ELISA, immunohistochemistry, Western blot, *etc.*

[00179] Alternatively, detecting the presence of a pathological Tau protein conformer in a subject using an Asp421 Epitope-specific antibody-based diagnostic molecule of the present invention can be achieved using *in vivo* imaging techniques. *In vivo* imaging involves administering to the subject the diagnostic antibody having antigenic specificity for a

pathological Tau peptide and detecting binding of the diagnostic antibody reagent to the pathological Tau protein conformer *in vivo*.

[00180] The Asp421 Epitope-specific antibody-based diagnostic molecules of the present invention can be administered by injection (*e.g.*, intravenous injection, intracarotid injection, *etc.*) into the body of the patient, or directly into the brain by intracranial injection. The dosage of such molecule should be from about 0.0001 mg/kg to about 100 mg/kg, and more usually from about 0.01 mg/kg to about 5 mg/kg, of the host body weight. For example, dosages can be about 1 mg/kg body weight or about 10 mg/kg body weight or within the range of about 1-10 mg/kg.

[00181] Typically, an Asp421 Epitope-specific antibody-based diagnostic molecule of the present invention is labeled, although in some methods, the molecule may be unlabeled and a secondary labeling agent is used to bind to such molecule (coupled or conjugated either directly to the molecule or indirectly, through an intermediate (such as, for example, a linker known in the art) using techniques known in the art). The choice of label depends on the means of detection. For example, a fluorescent label (such as a rare earth chelate (*e.g.*, a europium chelate)), a fluorescein-type label (*e.g.*, fluorescein, fluorescein isothiocyanate, 5-carboxyfluorescein, 6-carboxy fluorescein, dichlorotriazinylamine fluorescein), a rhodamine-type label (*e.g.*, ALEXA FLUOR® 568 (Invitrogen), TAMRA® or dansyl chloride), VIVOTAG 680 XL FLUOROCHROME™ (Perkin Elmer), phycoerythrin; umbelliferone, Lissamine; a cyanine; a phycoerythrin, Texas Red, BODIPY FL-SE® (Invitrogen) or an analogue thereof, is suitable for optical detection. Chemoluminescent labels may be employed (*e.g.*, luminol, luciferase, luciferin, and aequorin). Such diagnosis and detection can also be accomplished by coupling the diagnostic molecule of the present invention to detectable substances including, but not limited to, various enzymes, enzymes including, but not limited to, horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase, or to prosthetic group complexes such as, but not limited to, streptavidin/biotin and avidin/biotin. Paramagnetic labels and radioisotopic labels can also be employed, and are preferably detected using Positron Emission Tomography (PET) or Single-Photon Emission Computed Tomography (SPECT). Radiolabels include, but are not limited to, bismuth (^{213}Bi), carbon (^{11}C, ^{13}C, ^{14}C), chromium (^{51}Cr), cobalt (^{57}Co, ^{60}Co), copper (^{64}Cu), dysprosium (^{165}Dy), erbium (^{169}Er), fluorine (^{18}F), gadolinium (^{153}Gd, ^{159}Gd), gallium (^{68}Ga, ^{67}Ga), germanium (^{68}Ge), gold (^{198}Au), holmium (^{166}Ho), hydrogen (^{3}H), indium (^{111}In,

^{112}In, ^{113}In, ^{115}In), iodine (^{121}I, ^{123}I, ^{124}I, ^{125}I, ^{131}I), iridium (^{192}Ir), iron (^{59}Fe), krypton (^{81m}Kr), lanthanium (^{140}La), lutelium (^{177}Lu), manganese (^{54}Mn), molybdenum (^{99}Mo), nitrogen (^{13}N, ^{15}N), oxygen (^{15}O), palladium (^{103}Pd), phosphorus (^{32}P), potassium (^{42}K), praseodymium (^{142}Pr), promethium (^{149}Pm), rhenium (^{186}Re, ^{188}Re), rhodium (^{105}Rh), rubidium (^{81}Rb, ^{82}Rb), ruthenium (^{82}Ru, ^{97}Ru), samarium (^{153}Sm), scandium (^{47}Sc), selenium (^{75}Se), sodium (^{24}Na), strontium (^{85}Sr, ^{89}Sr, ^{92}Sr), sulfur (^{35}S), technetium (^{99}Tc), thallium (^{201}Tl), tin (^{113}Sn, ^{117}Sn), xenon (^{133}Xe), ytterbium (^{169}Yb, ^{175}Yb, ^{177}Yb), yttrium (^{90}Y), and zinc (^{65}Zn) and zirconium (^{89}Zr); positron emitting metals using various positron emission tomographies, and non-radioactive paramagnetic metal ions (such as paramagnetic ions of Aluminum (Al), Barium (Ba), Calcium (Ca), Cerium (Ce), Dysprosium (Dy), Erbium (Er), Europium (Eu), Gandolinium (Gd), Holmium (Ho), Iridium (Ir), Lithium (Li), Magnesium (Mg), Manganese (Mn), Molybdenum (M), Neodymium (Nd), Osmium (Os), Oxygen (O), Palladium (Pd), Platinum (Pt), Rhodium (Rh), Ruthenium (Ru), Samarium (Sm), Sodium (Na), Strontium (Sr), Terbium (Tb), Thulium (Tm), Tin (Sn), Titanium (Ti), Tungsten (W), and Zirconium (Zr), and particularly, Co^{+2}, CR^{+2}, Cr^{+3}, Cu^{+2}, Fe^{+2}, Fe^{+3}, Ga^{+3}, Mn^{+3}, Ni^{+2}, Ti^{+3}, V^{+3}, and V^{+4}). Methods for preparing radiolabeled amino acids and related peptide derivatives are known in the art (see for instance Junghans *et al.*, in Cancer Chemotherapy and Biotherapy 655-686 (2nd edition, Chafner and Longo, eds., Lippincott Raven (1996)) and US Patents No. 4,681,581; 4,735,210; 5,101,827; 5,102,990; RE 35,500; 5,648,471 and 5,697,902. For example, a radioisotope may be conjugated by a chloramine-T method (Lindegren, S. *et al.* (1998) *"Chloramine-T In High-Specific-Activity Radioiodination Of Antibodies Using N-Succinimidyl-3-(Trimethylstannyl)Benzoate As An Intermediate,"* Nucl. Med. Biol. 25(7):659-665; Kurth, M. *et al.* (1993) *"Site-Specific Conjugation Of A Radioiodinated Phenethylamine Derivative To A Monoclonal Antibody Results In Increased Radioactivity Localization In Tumor,"* J. Med. Chem. 36(9):1255-1261; Rea, D.W. *et al.* (1990) *"Site-specifically radioiodinated antibody for targeting tumors,"* Cancer Res. 50(3 Suppl):857s-861s).

[00182]   Diagnosis is performed by comparing the number, size, and/or intensity of labeled pathological Tau conformers, Tau aggregates, and/or neurofibrillary tangles in a sample from the subject, or in the subject, to corresponding baseline values. The base line values can represent the mean levels in a population of non-diseased individuals. Baseline values can also represent previous levels determined in the same subject.

[00183]   The diagnostic methods described above can also be used to monitor a subject's response to therapy. In this embodiment, detecting the presence of pathological Tau in a subject is determined prior to the commencement of treatment. The level of pathological Tau in the subject at this time point is used as a baseline value. At various times during the course of treatment the detection of pathological Tau protein conformers, Tau aggregates, and/or neurofibrillary tangles is repeated, and the measured values thereafter compared with the baseline values. A decrease in values relative to baseline signals a positive response to treatment. Values can also increase temporarily in biological fluids as pathological Tau is being cleared from the brain.

[00184]   The present invention is further directed to a kit for performing the above-described diagnostic and monitoring methods. Typically, such kits contain the diagnostic antibody of the present invention. The kit can also include a detectable label. The diagnostic antibody itself may contain the detectable label (e.g., fluorescent molecule, biotin, *etc.*) which is directly detectable or detectable via a secondary reaction (e.g., reaction with streptavidin). Alternatively, a second reagent containing the detectable label may be utilized, where the second reagent has binding specificity for the primary antibody. In a diagnostic kit suitable for measuring pathological Tau protein in a biological sample, the antibodies of the kit may be supplied pre-bound to a solid phase, such as to the wells of a microtiter dish.

[00185]   The presence of labeled anti-Tau antibodies or their Tau-binding fragments may be detected *in vivo* for diagnosis purposes. In one embodiment, such diagnosis comprises: a) administering to a subject an effective amount of such labeled molecule; b) waiting for a time interval following administration in order to allow the labeled molecule to concentrate at sites (if any) of aggregated Tau and to allow unbound labeled molecule to be cleared to a background level; c) determining a background level; and d) detecting such labeled molecule in the subject, such that detection of labeled molecule above the background level is indicative that the subject has a tauopathy, or is indicative of the severity of such tauopathy. In accordance with such embodiment, the antibody is labeled with an imaging moiety suitable for detection using a particular imaging system known to those skilled in the art. Background levels may be determined by various methods known in the art, including comparing the amount of labeled molecule detected to a standard value previously determined for a particular imaging system. Methods and systems that may be used in the diagnostic methods of the invention include, but are not limited to, computed tomography (CT), whole body scan

such as positron emission tomography (PET), magnetic resonance imaging (MRI), and sonography.

B.   Therapeutic Utility

[00186]   As indicated above, one aspect of the present invention relates to a method of preventing or treating Alzheimer's disease or other tauopathy in a subject via the administration of an effective amount of an Asp421 Epitope-specific antibody-based molecule of the present invention (especially Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 or Antibody 5G2A3, or an scFv fragment thereof) in an amount effective to prevent or treat such Alzheimer's disease or other tauopathy. Such administration may be provided in order to promote the clearance of Tau aggregates from the brain of a subject or may be provided in order to slow a tangle-related behavioral phenotype in a subject. Additionally, such administration may be provided prophylactically in order to delay, impede, attenuate or prevent the onset of Alzheimer's disease, or other tauopathy associated with the neurofibrillary tangle.

[00187]   The term "**treatment**" or "**treating**" as used herein means ameliorating, slowing or reversing the progress or severity of a disease or disorder, or ameliorating, slowing or reversing one or more symptoms or side effects of such disease or disorder. For purposes of this invention, "treatment" or "treating" further means an approach for obtaining beneficial or desired clinical results, where "beneficial or desired clinical results" include, without limitation, alleviation of a symptom, diminishment of the extent of a disorder or disease, stabilized (i.e., not worsening) disease or disorder state, delay or slowing of the progression a disease or disorder state, amelioration or palliation of a disease or disorder state, and remission of a disease or disorder, whether partial or total, detectable or undetectable.

[00188]   An "**effective amount**," when applied to an antibody of the invention, refers to an amount sufficient, at dosages and for periods of time necessary, to achieve an intended biological effect or a desired therapeutic result including, without limitation, clinical results. The phrase "therapeutically effective amount" when applied to an antibody of the invention is intended to denote an amount of the antibody that is sufficient to ameliorate, palliate, stabilize, reverse, slow or delay the progression of a disorder or disease state, or of a symptom of the disorder or disease. In an embodiment, the method of the present invention provides for administration of the antibody in combinations with other compounds. In such

instances, the "effective amount" is the amount of the combination sufficient to cause the intended biological effect.

[00189]   An amount adequate to accomplish therapeutic or prophylactic treatment is defined, respectively, as a therapeutically effective dose or a prophylactically effective dose. In both prophylactic and therapeutic regimes, agents are usually administered in several dosages until a sufficient immune response has been achieved. Typically, the immune response is monitored and repeated dosages are given if the immune response starts to wane. A therapeutically effective or prophylactically effective dose of such an antibody or epitope-binding fragment thereof may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the molecule to elicit a desired response in the subject. A therapeutically effective amount is also one in which any toxic or detrimental effects of the antibody or antibody portion are outweighed by the therapeutically beneficial effect.

[00190]   Patients amenable to treatment include individuals having Alzheimer's disease or such other tauopathy who show clinically recognized symptoms or indications of such conditions, as well as patients not presently showing symptoms of such conditions. Although Alzheimer's disease is definitively diagnosed only *post-mortem* biopsy, individuals suffering from Alzheimer's disease are clinically diagnosed using the *"Alzheimer's Disease and Related Disorders Association* ("ADRDA") Criteria (Carrillo, M.C. *et al.* (2013) *"Revisiting The Framework Of The National Institute On Aging-Alzheimer's Association Diagnostic Criteria,"* Alzheimers Dement. 9(5):594-601; Budson, A.E. *et al.* (2012) *"New Criteria For Alzheimer Disease And Mild Cognitive Impairment: Implications For The Practicing Clinician,"* Neurologist 18(6):356-363; Sarazin, M. *et al.* (2012) *"Clinical And Research Diagnostic Criteria For Alzheimer's Disease,"* Neuroimaging Clin. N. Amer. 22(1):23-32; Husain, M.M. (2005) *"Clinical Diagnosis And Management Of Alzheimer's Disease,"* Neuroimaging Clin. N. Amer. 15(4):767-777; Small, G.W. *et al.* (1997) *"Diagnosis And Treatment Of Alzheimer Disease And Related Disorders. Consensus Statement Of The American Association For Geriatric Psychiatry, The Alzheimer's Association, And The American Geriatrics Society,"* JAMA 278(16):1363-1371). Such individuals can alternatively be distinguished from those having diseases or conditions that are un-related to Alzheimer's disease or other tauopathy by the presence of correlated risk factors (*i.e.*, one or more factors that have been found to possess greater than 50% coincidence with Alzheimer's

disease or such other tauopathy). Such correlated risk factors include the finding that a patient has had relatives who have experienced Alzheimer's disease or such other tauopathy, or present a family history of hypercholesterolemia or atherosclerosis. Such correlated risk factors particularly include the finding that a patient possesses one or more genetic or biochemical markers that have been correlated with (*i.e.*, found to possess greater than 50% coincidence with) the occurrence of such actual disease. Examples of such genetic markers of risk toward Alzheimer's disease include correlated mutations in the APP gene, for example, mutations at position 717 and positions 670 and 671 of the APP gene (referred to as the Hardy and Swedish mutations respectively). Other suitable markers of known genetic risk include correlated mutations in the presenilin genes (PS1 and PS2) and in the ApoE4 gene (Bekris, L.M. *et al.* (2010) "*Genetics of Alzheimer Disease,*" J. Geriatr. Psychiatry Neurol. 23(4):213–227).

[00191]   The amino acid sequence of isoform 1 of PS1 is (**SEQ ID NO:103**):

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MTELPAPLSY  FQNAQMSEDN  HLSNTVRSQN  DNRERQEHND  RRSLGHPEPL
SNGRPQGNSR  QVVEQDEEED  EELTLKYGAK  HVIMLFVPVT  LCMVVVVATI
KSVSFYTRKD  GQLIYTPFTE  DTETVGQRAL  HSILNAAIMI  SVIVVMTILL
VVLYKYRCYK  VIHAWLIISS  LLLLFFFSFI  YLGEVFKTYN  VAVDYITVAL
LIWNFGVVGM  ISIHWKGPLR  LQQAYLIMIS  ALMALVFIKY  LPEWTAWLIL
AVISVYDLVA  VLCPKGPLRM  LVETAQERNE  TLFPALIYSS  TMVWLVNMAE
GDPEAQRRVS  KNSKYNAEST  ERESQDTVAE  NDDGGFSEEW  EAQRDSHLGP
HRSTPESRAA  VQELSSSILA  GEDPEERGVK  LGLGDFIFYS  VLVGKASATA
SGDWNTTIAC  FVAILIGLCL  TLLLLAIFKK  ALPALPISIT  FGLVFYFATD
YLVQPFMDQL  AFHQFYI
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[00192]   Such PS1 mutations include the substitutions: R35Q; A79V; V82L; L85P; V89L; V94M; V96F; V97L; F105I; F105L; F105V; L113P; L113Q; Y115C; Y115D; Y115H; T116I; T116N; P117A; P117L; P117R; P117S; E120D; E120D; E120G; E120K; E123K; N135D; N135S; A136G; M139I; M139I; M139K; M139T; M139V; I143F; I143M; I143N; I143T; I143V; M146I; M146I; M146I; M146L; M146L; M146V; T147I; L153V; Y154C; Y154N; H163R; H163Y; W165C; W165G; L166H; L166P; L166R; S169L; S169P; S170F; L171P; L173F; L173W; L174M; L174R; F175S; F177L; F177S; S178P; G183V; E184D; V191A; G206A; G206D; G206S; G206V; G209E; G209R; G209V; S212Y; I213F; I213L; I213T; H214D; H214Y; G217D; G217R; L219F; L219P; Q222H; Q222R; Q223R; L226F; L226R; I229F; A231T; A231V; M233I; M233L; M233L; M233T; M233V; L235P; L235V; F237I; F237L; K239N; T245P; A246E; L248R; L250S; L250V; Y256S; A260V; V261F; V261L; L262F; C263F; C263R; P264L; G266S; P267L; P267S; R269G; R269H; L271V; V272A; E273A; T274R; R278I; R278K; R278S; R278T; E280A; E280G; L282F; L282R;

L282V; P284L; P284S; A285V; L286P; L286V; T291P; E318G; R358Q; S365A; R377M; G378E; G378V; L381V; G384A; F386S; S390I; V391F; L392P; L392V; G394V; N405S; A409T; C410Y; V412I; L418F; L420R; L424F; L424H; L424R; L424V; A426P; A431E; A431V; A434C; L435F; P436Q; P436S; and I439S.

[00193]   The amino acid sequence of isoform 1 of PS2 is (**SEQ ID NO:104**):

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MLTFMASDSE  EEVCDERTSL  MSAESPTPRS  CQEGRQGPED  GENTAQWRSQ
ENEEDGEEDP  DRYVCSGVPG  RPPGLEEELT  LKYGAKHVIM  LFVPVTLCMI
VVVATIKSVR  FYTEKNGQLI  YTPFTEDTPS  VGQRLLNSVL  NTLIMISVIV
VMTIFLVVLY  KYRCYKFIHG  WLIMSSLMLL  FLFTYIYLGE  VLKTYNVAMD
YPTLLLTVWN  FGAVGMVCIH  WKGPLVLQQA  YLIMISALMA  LVFIKYLPEW
SAWVILGAIS  VYDLVAVLCP  KGPLRMLVET  AQERNEPIFP  ALIYSSAMVW
TVGMAKLDPS  SQGALQLPYD  PEMEEDSYDS  FGEPSYPEVF  EPPLTGYPGE
ELEEEEERGV  KLGLGDFIFY  SVLVGKAAAT  GSGDWNTTLA  CFVAILIGLC
LTLLLLAVFK  KALPALPISI  TFGLIFYFST  DNLVRPFMDT  LASHQLYI
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[00194]   Such PS2 mutations include the substitutions: R29H; G34S; R62C; R62H; R71W; A85V; T122P; T122R; S130L; V139M; N141I; L143H; V148I; R163H; M174V; S175C; Y231C; Q228L; M239V; M230I; A252T; P334R; T430M; and D439A.

[00195]   Such ApoE4 alleles include the ε4 allele, ε3 allele and ε2 allele (Verghese, P.B. *et al.* (2011) *"Apolipoprotein E In Alzheimer's Disease And Other Neurological Disorders,"* Lancet Neurol. 10(3):241-252).

[00196]   In addition, a number of diagnostic tests are available for identifying individuals who have Alzheimer's disease. These include measurement of CSF Tau and Aβ42 levels. Elevated Tau and decreased Aβ42 levels signify the presence of Alzheimer's disease.

[00197]   In the case of Alzheimer's disease, virtually anyone is at risk of suffering from Alzheimer's disease. Therefore, the therapeutic molecules of the present invention can be administered prophylactically to the general population without the need for any assessment of the risk of the subject patient. The present methods are especially useful for the prophylactic treatment of individuals who do have a known genetic risk of Alzheimer's disease. 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, 70, 80 or 90 years of age. Treatment typically entails the administration of multiple dosages over a period of time. Treatment can be monitored by assaying antibody, or activated T-cell or B-cell responses to the therapeutic agent over time. If the response falls, a booster dosage is indicated. In the case of potential Down's syndrome patients, treatment can begin ante-natally

by administering the therapeutic agent to the mother during pregnancy or shortly after the patient's birth.

[00198]   The present invention provides:

1.   A binding molecule that is capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau.

2.   The embodiment of such binding molecule wherein the molecule competes for binding with an antibody selected from the group consisting of: Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 and 5G2A3.

3.   The embodiment of such binding molecule wherein the molecule comprises:

(a)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:9, 10 and 11**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:13, 14 and 15**;

(b)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:17, 18 and 19**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:21, 22 and 23**;

(c)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:25, 26 and 27**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:33, 34 and 35**;

(d)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:29, 30 and 31**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:33, 34 and 35**;

(e)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:37, 38 and 39**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:41, 42 and 43**;

(f)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:45, 46 and 47**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:49, 50 and 51**.

4.   The embodiment of such binding molecule wherein the molecule comprises:

    (a)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:115, 116 and 117**; and

    (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:118, 119 and 120**.

5.   The embodiment of any such binding molecules wherein upon peripheral injection into a recipient, the molecule substantially co-localizes with a Tau aggregate.

6.   The embodiment of any such binding molecules wherein the molecule is an antibody, a diabody, an scFv, or comprises an epitope-binding fragment of an antibody, diabody or scFv.

7.   The embodiment of any such binding molecules wherein the molecule is an antibody.

8.   The embodiment of any such binding molecules, wherein the molecule is the Antibody 1G10D2, the Antibody 1G11A10, the Antibody 5B3C11 or the Antibody 5G2A3.

9.   The embodiment of any of the above-described binding molecules, wherein the molecule immunospecifically binds to the Tau 407-421 peptide (**SEQ ID NO:7**): HLSNVSSTGSIDMVD.

10.   The embodiment of any of the above-described binding molecules, which is detectably labeled.

11.   The embodiment of any of the above-described detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label.

12.   (A)   The embodiment of any of the above-described detectably labeled binding molecules for use in the manufacture of a medicament for detecting or measuring the presence or amount of pathological Tau protein in the brain of, or in a biological sample of, a recipient subject, or

    (B)   the use of any of the above-described detectably embodiments of labeled binding molecules for detecting or measuring the presence or amount of the pathological Tau protein in the brain of, or in a biological sample of, a recipient subject.

13.   (A)   The embodiment of any of the above-described detectably labeled binding molecules for use in the manufacture of a medicament for detecting or measuring the presence or amount of pathological Tau protein in the brain of, or in a biological sample of, a recipient subject, or

(B) the use of any of the above-described embodiments of detectably labeled binding molecules for detecting or measuring the presence or amount of the pathological Tau protein in the brain of, or in a biological sample of, a recipient subject;

wherein the detection or measurement comprises *in vivo* imaging of the binding molecule bound to the truncated Tau protein.

14. (A) The embodiment of any of the above-described detectably labeled binding molecules for use in the manufacture of a medicament for detecting or measuring the presence or amount of pathological Tau protein in the brain of, or in a biological sample of, a recipient subject, or

(B) the use of any of the above-described embodiments of detectably labeled binding molecules for detecting or measuring the presence or amount of the pathological Tau protein in the brain of, or in a biological sample of, a recipient subject;

wherein the detection or measurement comprises *ex vivo* imaging of the binding molecule bound to the truncated Tau protein.

15. (A) (1) The embodiment of any of the above-described binding molecules, which is detectably labeled; or

(2) the embodiment of any of the above-described detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label;

for use in the manufacture of a medicament for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(B) (1) the use of any of the above-described embodiments of detectably labeled binding molecules for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(2) the use of any of the above-described embodiments of detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label, for diagnosing Alzheimer's disease or another tauopathy of a subject.

16. (A) (1) The embodiment of any of the above-described binding molecules, which is detectably labeled; or

(2)　　the embodiment of any of the above-described detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label;

for use in the manufacture of a medicament for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(B)　　(1)　　the use of any of the above-described embodiments of detectably labeled binding molecules for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(2)　　the use of any of the above-described embodiments of detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label, for diagnosing Alzheimer's disease or another tauopathy of a subject;

wherein the medicament is an *in vivo* medicament that is administered to the subject.

17.　　(A)　　(1)　　The embodiment of any of the above-described binding molecules, which is detectably labeled; or

(2)　　the embodiment of any of the above-described detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label;

for use in the manufacture of a medicament for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(B)　　(1)　　the use of any of the above-described embodiments of detectably labeled binding molecules for diagnosing Alzheimer's disease or another tauopathy of a subject; or

(2)　　the use of any of the above-described embodiments of detectably labeled binding molecules, wherein the detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label, for diagnosing Alzheimer's disease or another tauopathy of a subject;

wherein the medicament is incubated *ex vivo* with a biopsy sample of the subject.

18.　　The embodiment of any of such uses, wherein the tauopathy is selected from the group comprising frontotemporal dementia, parkinsonism linked to chromosome 17

(FTDP-17), progressive supranuclear palsy, corticobasal degeneration, Pick's disease, progressive subcortical gliosis, tangle only dementia, diffuse neurofibrillary tangles with calcification, argyrophilic grain dementia, amyotrophic lateral sclerosis parkinsonism-dementia complex, dementia pugilistica, Down syndrome, Gerstmann-Straussler-Scheinker disease, Hallerworden-Spatz disease, inclusion body myositis, Creutzfeld- Jakob disease, multiple system atropy, Niemann-Pick disease type C, prion protein cerebral amyloid angiopathy, subacute sclerosing panencephalitis, myotonic dystrophy, non-guanamian motor neuron disease with neurofibrillary tangles, postencephalitic parkinsonism, acute traumatic brain injury and chronic traumatic encephalopathy.

Examples

[00199]   The following examples illustrate various methods for compositions in the diagnostic or treatment methods of the invention. The examples are intended to illustrate, but in no way limit, the scope of the invention.

Example 1
Specificity of Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 (or Antibody 5G2G6) for the Truncated Asp421 Epitope of Tau

[00200]   In order to demonstrate the ability of Antibodies Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11, Antibody 5G2A3 / 5G2G6 to immunospecifically bind to the Truncated Asp421 Epitope of Tau, antibody preparations were incubated in the presence of an immobilized peptide corresponding either to Tau residues 407-421 (**SEQ ID NO:7**) or 407-423 (**SEQ ID NO:105**) (corresponding, respectively, to residues 407-421 and 407-423, respectively of **SEQ ID NO:1**), and the amount of antibody bound to the immobilized peptide was determined via ELISA. Antibody 1G10D2 (**Figure 1A**), Antibody 1G11A10 (**Figure 1B**), Antibody 5B3C11 (**Figure 1C**), Antibody 5G2A3 (**Figure 1D**) and Antibody 5G2G6 (**Figure 1E**) were each found to be capable of strongly binding to the truncated (Tau 407-421) peptide (**SEQ ID NO:7**), but incapable of binding a peptide (Tau 407-423; **SEQ ID NO:105**) that contained the non-truncated epitope. The data thus confirms the ability of Antibodies 1G11A10, 5G2A3 and 5G2G6 to immunospecifically bind to the Truncated Asp421 Epitope of Tau.

[00201]   As shown in **Figures 2A-2B**, the binding affinity profiles of Antibodies 1G11A10 and 5G2A3 differ, with Antibody 1G11A10 binding to the Truncated Asp421

Epitope with lower affinity, such that less binding is observed at higher antibody dilution (**Figure 2A**), relative to Antibody 5G2A3 which exhibits high affinity binding to the Truncated Asp421 Epitope even at very low antibody concentration (**Figure 2B**).

[00202]   The binding affinity inferred from the ELISA data was confirmed by Biacore analysis. The results of the analysis are shown in **Table 7**.

Table 7		
Analyte	**Antibody 5G2A3**	**Antibody 1G11A10**
Tau407-421 (SEQ ID NO:7)	7.46×10^{-9}	1.07×10^{-6}
Tau407-423 (SEQ ID NO:105)	5.07×10^{-6}	No Binding

[00203]   Thus, Antibody 5G2A3 targets the Truncated Asp421 Epitope and binds with a high affinity (10^{-9} M). In contrast, antibody 1G11A10 binds the Truncated Asp421 Epitope with lower affinity (10^{-6} M), but does not detectably bind to the non-truncated epitope.

Example 2
Ability of Antibodies Recognizing the Asp421 Epitope
of Tau to Clear Pathological Tau

[00204]   Immunotherapy using monoclonal antibodies against Tau epitopes such as the "$^{\{P\}}$Ser396/$^{\{P\}}$Ser404 Tau Epitope," which involves Tau having phosphoserine residues at positions 396 and 404 ($^{\{P\}}$Ser396 and $^{\{P\}}$SerSer404), has demonstrated a reduction in the hyperphosphorylated Tau levels and the pathology associated with it. In order to further demonstrate the therapeutic capabilities of the Truncated Tau Epitope-binding molecules of the present invention, the ability of monoclonal Antibodies 5G2A3 / 5G2G6 and 1G11A10, which immunospecifically bind to the Truncated Asp421 Epitope to affect hyperphosphorylated Tau was explored using primary neuronal cultures. In addition, the ability of Antibodies 5G2A3 and 1G11A10 to affect hyperphosphorylated Tau was explored using mixed cortical cultures.

[00205]   Accordingly, primary neurons and mixed cortical cultures from Day 0 JNPL3 mice were pretreated with PHF (1 µg/mL) for 24 h followed by the addition of Antibody 5G2A3 / 5G2G6 (only pure neuronal cultures) or Antibody 1G11A10 (10 µg/mL) for an additional 24 h, 48 h, 72 h or 96 h. Immunoblots were undertaken against antibody PHF-1

(which binds a $^{\{P\}}$Ser396/$^{\{P\}}$Ser404 epitope), anti-human Tau antibody (Dako) and phosphorylated Tau ($^{\{P\}}$Ser199).

[00206]   **Table 8** shows the results of this experiment for the mixed neuronal cultures pretreated with PHF.

Table 8							
	PHF-Treated Cells (PHF-1 Chemoluminescent Signal Values)						
	24hr		**48hr**		**72hr**		**96hr**
	751300		1224982		1622299		1828209
	688635		1321391		1523903		1729813
	670977		1449190		1637642		1843552
	645829		1507930		1629707		1835617
	649657		1380862		1595397		1801307
	425133		1354053		1648179		1854089
Mean	638588.5		1373068		1609521		1815431
SD	111351.5		98999.8		45576.12		45576.14
	IgG-Treated Cells (PHF-1 Chemoluminescent Signal Values)						
	24hr		**48hr**		**72hr**		**96hr**
	583074		1422041		1443397		2201538
	641161		1417630		1464404		1814748
	708202		1457702		1662020		1766616
	688516		1373635		1521455		1679659
	687360		1320653		1834901		1629244
	622845		1417484		1512274		1574982
Mean	655193		1401524		1573075		1818361
SD	47748.37		47768		149299.2		225335.3
	5G2A3-Treated Cells (PHF-1 Chemoluminescent Signal Values)						
	24hr		**48hr**		**72hr**		**96hr**
	571503		435510.8		543829.3		229600
	399505		418450.8		533115.5		212540
	413940		418883.4		445210		212973
	413921		464627.2		539038.1		258717
	408297		434414.7		425200.4		228504
	322745		471881.4		535928.9		265971
Mean	421651.8		440628		503720.4		234717.5
SD	81272.39		22725.25		53565.64		22725.4

Table 8							
	1G11A10-Treated Cells (PHF-1 Chemoluminescent Signal Values)						
	24hr		48hr		72hr		96hr
	351671		414222.4		606166.6		543586
	568261		423511.5		595803.6		636088
	436208		425164.2		570901.7		918583
	382948		432781.3		630724.7		1165849
	313133		435635.4		559424.1		1209264
	257632		460723.8		556335.5		1141208
Mean	384975.5		432006.4		586559.4		935763
SD	108359.9		15960.63		29378.37		287698.8

[00207]   The data of **Table 8** are shown graphically in **Figure 3A**. The data show that such cells (postnatal day 0) have significantly decreased levels of PHF-1 ($^{\{P\}}$Ser396/$^{\{P\}}$Ser404) after treatment with antibody 5G2A3 and 1G11A10 when compared to control cells, p<0.0001.

[00208]   **Table 9** shows the results of this experiment for the mixed neuronal cultures immunoblotted with anti-human Tau antibody (Dako) to thus show total Tau.

Table 9							
	PHF-Treated (Total Tau values)						
	24hr		48hr		72hr		96hr
	1273302		2097159		1771592		2651642
	1361667		1949165		1749614		2463713
	1389425		1631917		2058003		2738844
	1315507		1827079		1916164		2308258
	1403872		1893961		2156769		2442688
	1431630		1873666		1672630		3030670
Mean	1380420		1878825		1930428		2605969
SD	58959.05		152653		190270.9		259091.5
	IgG-Treated (Total Tau values)						
	24hr		48hr		72hr		96hr
	1510411		1809605		1824976		2575640
	1403872		2030118		1918718		2726928
	1347143		1807288		1864949		2688261
	1402882		1824177		2019845		2617819
	1415410		1982228		1810848		2657325
	1390445		1927370		2058342		2700656
Mean	1420475		1896798		1916280		2661105
SD	53881.43		96845.96		102956.8		56261.23

Table 9							
5G2A3-Treated (Total Tau values)							
	24hr		**48hr**		**72hr**		**96hr**
	1101694		1108014		1222242		883267.9
	991056		1090107		1145993		1042934
	1015557		1140544		1238038		1147477
	984736		1102489		1251133		974776
	985154		1029836		1133375		1242680
	1101469		1079134		527897		2025784
Mean	**1029944**		**1091687**		**1198156**		**1219487**
SD	**56626.95**		**36758.35**		**54531.71**		**414713.6**
1G11A10-Treated (Total Tau values)							
	24hr		**48hr**		**72hr**		**96hr**
	1036131		1533105		1374552		1717181
	982975		1502506		1751198		1750701
	916187		1547973		1606475		1798726
	968581		1464179		1446938		1763811
	978434		1464597		1790780		1628009
	1047353		1580912		1255174		1569623
Mean	**988276.8**		**1515545**		**1537520**		**1704675**
SD	**47937.2**		**46982.87**		**214026.5**		**88016.1**

[00209]   The data of **Table 9** are shown graphically in **Figure 4A**. The data show that 5G2A3 treatment was more effective in reducing the total Tau levels (54%, p<0.0001) at 96 h than 1G11A10 (36%, p<0.05) when compared to the control cells treated with IgG.

[00210]   The presence of the higher affinity antibody specific for the Truncated Asp421 Epitope (Antibody 5G2A3) led to significant and sustained reduction in both phospho-Tau (up to 87% at 96h, p<0.001) and total Tau (up to 54% at 96 h, p<0.0001) in the mixed culture, compared to control IgG which had no effect (**Figures 3A** and **4A**). This tau antibody had a pronounced effect in the primary neurons at 24 and 48 h (phospho-Tau: 89% reduction at both time points, p<0.001; total Tau: 58% at 24 h, p=0.001 and 45% at 48 h, p=0.005) that subsided slightly at the later time points (phospho-Tau: 75% reduction, p=0.003 at 72 h and 68% reduction at 96 h, p=0.008; total Tau: 6% reduction, p>0.05 at 72 h and 43% reduction, p=0.006 at 96 h; **Figures 3B** and **4B**).

[00211]   The presence of the lower affinity antibody specific for the Truncated Asp421 Epitope (Antibody 1G11A10) was less efficacious in reducing phospho-Tau and total Tau (up to 49% reduction at 96 h, p<0.0001 and 36% reduction at 96 h, respectively, p<0.0001) in the

mixed cortical culture (**Figures 3A** and **4A**), and was ineffective in the primary neuronal culture to reduce either phospho-Tau or total Tau (**Figures 3B** and **4B**).

[00212]   In conclusion, this study clearly shows: 1) the therapeutic efficacy of targeting Tau protein truncated at Asp421; 2) that higher affinity antibody against this particular epitope is more efficacious, and; 3) that greater efficacy is observed in mixed cortical cultures than in primary neurons, presumably because of contribution from phagocytic microglia that promote degradation of tau-antibody complexes.   Neurons in mixed cultures are also healthier and, therefore, likely to be better suited to clear/degrade such complexes.

[00213]   This study clearly demonstrates the ability of Antibody 5G2A3 to mediate a significant reduction of hyperphosphorylated Tau level, as well as significant reduction of total intracellular Tau level, in both mixed cortical cells and primary neuronal cells. This finding thus demonstrates the importance of the Asp421 epitope as a therapeutic target for Tau immunotherapy.

[00214]   These data indicate that multiple mechanisms are occurring, and that both extracellular blockage and promotion of intracellular clearance are valid methods for preventing seeding of tau pathology and associated toxicity. Antibodies that can affect both pathways are likely to be more efficacious than those acting only within one compartment.

Example 3
Treatment With Antibodies Targeting Asp421 Of The Tau Protein Prevents Toxicity Of, And Clears, Pathological Tau, With Associated Reduction In Microgliosis

[00215]   To elucidate the effects of antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, mixed cortical cultures and primary neurons were both pretreated with PHF (1μg/ml) for 24h followed by administration of Antibody 5G2A3 and Antibody 1G11A10 at 10μg/ml for a further 24h, 48h, 72h or 96h and the effect of such treatment on the clearance of intracellular Tau was assessed.

[00216]   The extent of intracellular Tau clearance was determined by undertaking Western immunoblot analysis on mixed cortical culture and primary neuronal culture from day 0 JNPL3 pups against phospho Ser 199 epitope. Both the mixed cortical and primary neuronal culture were pretreated with PHF (1μg/ml) for 24h followed by treatment with Antibody 5G2A3 (10μg/ml) or Antibody 1G11A10 (10μg/ml) antibodies for a further 24h, 48h, 72h or

96h. Antibody 5G2A3 illustrated reduction in the levels of phospho-Tau in both the mixed cortical as well as primary neurons.

[00217]   Total and phospho-Tau values were standardized against GAPDH to determine the effects of Antibody 5G2A3 and Antibody 1G11A10 in the clearance of PHF. A comparative analysis between the mixed cortical culture and primary neurons illustrated that Antibody 5G2A3 proved effective in reducing phospho-Tau in both the cell models with the maximum reduction observed at 96h (94%) (**Figure 5A**) for mixed cortical culture. In the primary neurons (**Figure 5B**), although the administration of Antibody 5G2A3 was found to be associated with a significant decrease in the levels of phospho Tau for all the time points, *i.e.*, from 24h until 96h, compared to the control cells that are treated with IgG (10µg/ml), a subtle increase in the levels of phospho Tau for the respective time points were observed plausibly depicting the inability of Antibody 5G2A3 in sustaining the reduction of phospho Tau levels within the primary neurons when compared with the mixed cortical culture.

[00218]   Antibody 1G11A10 treatment only proved effective in reducing phospho-Tau levels in primary neurons showing ~68% reduction from 24h until 72h, however, Antibody 1G11A10 treatment was found to be unable to significantly reduce the levels of phospho Tau in mixed cortical culture.

[00219]   A comparative analysis between mixed cortical culture and primary neurons illustrated reduction in the total Tau levels in both the cell types after Antibody 5G2A3 treatment. Western blots were undertaken against total Tau (Dako) both in the mixed cortical and primary neuronal cultures from day 0 JNPL3 mice. Both the cortical and primary neuronal culture were pretreated with PHF (1µg/ml) for 24h followed by treatment with Antibody 5G2A3 (10µg/ml) or Antibody 1G11A10 (10µg/ml) for further 24h, 48h, 72h or 96h. The cells treated with IgG (10µg/ml) were considered as control for both the mixed cortical culture and primary neurons. A sustained reduction (54%) in the total Tau levels from 48h until 96h was illustrated in the mixed cortical culture after Antibody 5G2A3 treatment (**Figure 6A**), whereas ~50% reduction was observed in the primary neurons at 24h, 48h and 96h (**Figure 6B**) illustrating the beneficial effect of Antibody 5G2A3 in reducing the total Tau levels in both the mixed cortical and primary neuronal culture.

[00220]   Antibody 1G11A10 proved effective in reducing the total Tau levels in the mixed cortical culture for 24h (41%) and 96h (36%) (**Figure 6A**), but a significant reduction in the

levels of total Tau was only evident at 48h (65%) in the primary neurons (**Figure 6B**) when compared to the control.

[00221] GAPDH was considered as a loading control for all the experiments. GAPDH levels did not change after Antibody 5G2A3 or Antibody 1G11A10 treatment in the mixed cortical and primary neurons. The mixed cortical culture and primary neuronal culture pretreated with PHF (1μg/ml) followed by Antibody 5G2A3 or Antibody 1G11A10 treatment at 10μg/ml each did not demonstrate any significant alteration in the levels of GAPDH levels, $p>0.05$ for 24h, 48h, 72h and 96h when compared to the IgG treated control.

[00222] In order to further characterize the effects of antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, NeuN and Iba1 levels were measured in the mixed cortical culture treated with Antibody 5G2A3 or Antibody 1G11A10. NeuN is used as a post-mitotic neuronal marker to determine the morpho-functional state of neurons, such that a decrease in the NeuN levels is suggestive of neuronal loss or damage. The Antibody 5G2A3-treated cells demonstrated a gradual increase in NeuN levels from 24h until 96h, with a statistically significant increase observed at 72h and 96h when compared to the control cells that were treated with IgG for the respective time points (**Figure 7**). No significant alteration in the levels of NeuN was observed for the Antibody 1G11A10-treated cells when compared to the control or cells treated with PHF only.

[00223] Iba1 is a glial specific marker that is known to be upregulated in the activated microglia. Iba1 was used as marker to investigate the effect of microglial activation as a result of PHF and antibody treatment. A significant decrease in the levels of Iba1 was observed in the Antibody 5G2A3-treated mixed cortical culture at 72h and 96h (**Figure 8**), relative to the control and cells treated with PHF only. Tau aggregates are known to activate microglia that in turn is known to cause stimulation of cytokine further leading to increased inflammatory response. Although increased microglial activation would further help in the clearance of PHF, a sustained increase in the microglia and inflammatory cytokines is also known to add to the overall pathology by causing elevated cellular injury. A decrease in Iba1 expression after Antibody 5G2A3 treatment is suggestive of a reduction in the inflammatory response mechanism following microglia-mediated clearance of antibody-tau complexes, whereas the less effective Antibody 1G11A10 treatment was unable to illustrate any significant alteration in the levels of Iba1 when compared to the control.

[00224]   A significant decrease in the phospho Tau (pSer199), total Tau and Iba1 levels with an increase in the NeuN levels in the Antibody 5G2A3-treated mixed cortical culture is possibly suggestive of the beneficial effect of Antibody 5G2A3 in the clearance of PHF by further reducing microglial activation, inflammatory response and maintaining the neuronal physiology that was observed through an increase in the NeuN expression.

Example 4
Co-incubation of High Dose PHF (10 μg/ml) with Antibodies That Are Immunospecific for the Truncated Asp421 Epitope of Tau (10 μg/ml) in Mixed Cortical Cultures

[00225]   To further elucidate the effects of antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, mixed neuronal cultures from Day 0 postnatal JNPL3 mice were co-incubated with PHF (10μg/ml) and Antibody 5G2A3 (10μg/ml) or Antibody 1G11A10 (10μg/ml) for a duration of 24h, 48h, 72h or 96h. Western immunoblots were performed against NeuN, and demonstrated a significant decrease in the levels of NeuN at 48h (27%), 72h (37%) and 96h (53%) for the cells treated with PHF only as well as for the PHF + IgG co-incubated cells, when compared to the untreated cells, $p < 0.0001$. No significant alteration in the NeuN level was observed for the Antibody 5G2A3 co-incubated cells from 24h until 72h, $p = 0.18$, whereas a sudden increase (122%, $p < 0.0001$) was observed at 96h when compared to the untreated cells. The cells co-incubated with Antibody 1G11A10 and PHF demonstrated no significant alteration in the levels of NeuN until 48h followed by a gradual decrease in the NeuN levels at 72h (18%) and 96h (24%) when compared to the untreated cells. The results of this investigation are shown in **Figure 9**.

[00226]   To further elucidate the effects of antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, mixed neuronal cultures from Day 0 postnatal JNPL3 mice were co-incubated with PHF (10μg/ml) and Antibody 5G2A3 (10μg/ml) or Antibody 1G11A10 (10μg/ml) for a duration of 24h, 48h, 72h or 96h. Immunoblots were performed against Ser199 epitope and were normalized against NeuN levels (**Figure 10**). The co-incubation of Antibody 5G2A3 antibody with PHF demonstrated significant decrease in the levels of phospho-Tau at 48h (78%), 72h (92%) and 96h (95%) compared to the cells treated with PHF only and PHF + IgG, $p < 0.0001$, whereas when compared with the untreated cells for the respective time points no significant alteration was observed in phospho-Tau levels for the cells co-incubated with Antibody 5G2A3 and PHF. The co-incubation of Antibody 1G11A10 antibody with PHF was unable to

demonstrate any significant alteration in the levels of phospho-Tau when compared to the cells treated with PHF only and PHF + IgG for all time points.

[00227]   Mixed neuronal cultures from Day 0 postnatal JNPL3 mice were also co-incubated with PHF (10μg/ml) and antibodies that are capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau (Antibody 5G2A3 (10μg/ml) and Antibody 1G11A10 (10μg/ml)) for a duration of 24h, 48h, 72h or 96h. Immunoblots were performed against Tau (Dako) which recognizes both phosphorylated as well as non-phosphorylated tau species within the cells. The values were normalized against NeuN (**Figure 11**). Amongst the Antibody 5G2A3 and Antibody 1G11A10 antibodies, only Antibody 5G2A3 proved effective in reducing the total Tau levels, demonstrating 32%, 37% and 91% reduction at 48h, 72h and 96h respectively compared to the control cells (cells treated with PHF + IgG) with $p<0.0001$. Antibody 1G11A10 was ineffective in reducing the total Tau levels for all the time points when compared to the control cells.

[00228]   Mixed neuronal cultures from Day 0 postnatal JNPL3 mice were also co-incubated with PHF (10μg/ml) and Antibody 5G2A3 (10μg/ml) or Antibody 1G11A10 (10μg/ml) for a duration of 24h, 48h, 72h or 96h and immunoblots were performed against Iba1 to demonstrate the effect of such antibody administration on microglial activity. The co-incubation of Antibody 5G2A3 antibody with PHF did not demonstrate any significant alteration in Iba1 levels when compared to the untreated control cells, whereas a significant increase in the levels of Iba1 was observed for the cells treated with PHF only, PHF + IgG and PHF+Antibody 1G11A10 for 72h and 96h, $p<0.0001$ (**Figure 12**).

Example 5
Tissue Reactivity in Tauopathy Mice of Antibodies That Are Immunospecific for the Truncated Asp421 Epitope of Tau

[00229]   In order to assess the tissue reactivity of antibody that are immunospecific for the Truncated Asp421 Epitope of Tau, a dot blot analysis was conducted on brain supernatant samples from JNPL3 tauopathy mice (**Figure 13A**) and from hTau tauopathy mice (**Figure 13B**).

[00230]   With regard to the JNPL3 tauopathy mice (**Figure 13A**), a stronger signal was detected in most of the mice with the higher affinity Antibody 5G2A3. However, the lower affinity Antibody 1G11A10 gave a stronger signal in some of the mice, suggesting that the exact epitope recognized by these two antibodies differed. The anti-Tau antibody, C3, a

commerically available antibody (Millipore Sigma; Abcam; Delobel, P. *et al.* (2008) *"Analysis of Tau Phosphorylation and Truncation in a Mouse Model of Human Tauopathy,"* Am. J. Pathol. 172(1):123-131) against the same epitope, showed the lowest signal in nearly all the samples.

Example 6
Tissue Reactivity in Brain Supernatant Samples from Human (Control) Brain and Purified PHF from Human AD Brain

An assessment of the tissue reactivity of antibody that are immunospecific for the Truncated Asp421 Epitope of Tau was also conducted on brain supernatant samples from human (control) brain and from PHF that had been purified from human AD brain. The results of this investigation are shown in **Figure 14**. In human samples, Antibody 5G2A3 gives the strongest signal detecting PHF material isolated from an Alzheimer's brain. It also has the best specificity as it has a low signal in control brain supernatant (C1-C6). Antibody 1G11A10 and commercial C3 antibody have comparable signal detecting pathological PHF material, but Antibody 1G11A10 has better specificity as it has lower signal than C3 in control brains.

[00231] All publications and patents mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference in its entirety. While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

What Is Claimed Is:

Claim 1.   An antibody-based molecule that is capable of immunospecifically binding to the Truncated Asp421 Epitope of Tau, wherein said epitope is present on a peptide having the sequence of Tau 407-421 (**SEQ ID NO:7**): HLSNVSSTGSIDMVD.

Claim 2.   The antibody-based molecule of claim 1, wherein said molecule competes for binding with an antibody selected from the group consisting of: Antibody 1G10D2, Antibody 1G11A10, Antibody 5B3C11 and Antibody 5G2A3.

Claim 3.   The antibody-based molecule of claim 1, wherein said molecule comprises:

(a)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:9, 10** and **11**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:13, 14** and **15**;

(b)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:17, 18** and **19**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:21, 22** and **23**;

(c)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:25, 26** and **27**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:33, 34** and **35**;

(d)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the amino acid sequence of **SEQ ID NOs:29, 30** and **31**; and

(2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively
        having the amino acid sequence of **SEQ ID NOs:33, 34** and
        35;

or

(e)   (1)   a Variable Light Chain CDR1, CDR2, CDR3 respectively
                having the amino acid sequence of **SEQ ID NOs:37, 38** and
                39; and

        (2)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively
                having the amino acid sequence of **SEQ ID NOs:41, 42** and
                43.

Claim 4.   The antibody-based molecule of claim 1, wherein said molecule comprises:

(a)   a Variable Light Chain CDR1, CDR2, CDR3 respectively having the
        amino acid sequence of **SEQ ID NOs:97, 98** and **99**; and

(b)   a Variable Heavy Chain CDR1, CDR2, CDR3 respectively having the
        amino acid sequence of **SEQ ID NOs:100, 101** and **102**.

Claim 5.   The antibody-based molecule of any of claims 1-4, wherein upon peripheral
injection into a recipient, said molecule substantially co-localizes with a Tau
aggregate.

Claim 6.   The antibody-based molecule of any one of claims 1-5, wherein said molecule
is an antibody, a diabody, an scFv, or comprises an epitope-binding fragment
of an antibody, diabody or scFv.

Claim 7.   The antibody-based molecule of claim 6, wherein said molecule is an
antibody.

Claim 8.   The antibody-based molecule of claim 6, wherein said molecule is a
humanized antibody or comprises an epitope-binding fragment of a humanized
antibody.

Claim 9.   The antibody-based molecule of claim 6, wherein said molecule is an scFv.

Claim 10.   The antibody-based molecule of any of claims 1-9, which is detectably
labeled.

Claim 11.   The antibody-based molecule of claim 10, wherein said detectable label is a fluorescent label, a chemoluminescent label, a paramagnetic label, a radioisotopic label or an enzyme label.

Claim 12.   Use of the antibody-based molecule of any of claims 10-11 for detecting or measuring the presence or amount of said truncated Tau protein in the brain, cerebrospinal fluid, blood, serum or plasma of a recipient subject.

Claim 13.   The use of claim 12, wherein said detection or measurement comprises *in vivo* or *ex vivo* imaging of said antibody-based molecule bound to said truncated Tau protein.

Claim 14.   The use of any of claims 12-13, wherein said detection or measurement is for diagnosing Alzheimer's disease or another tauopathy of a subject.

Claim 15.   An *in vivo* medicament for the treatment of Alzheimer's disease or another tauopathy of a subject, wherein said medicament comprises the antibody-based molecule of any of claims 1-9 in an amount effective to treat said Alzheimer's disease or other tauopathy, and one or more carriers, diluents and/or stabilizers.

Claim 16.   Use of the *vivo* medicament of claim 13 for the treatment of Alzheimer's disease or another tauopathy of said subject.

Claim 17.   The use of any of claims 12-16, wherein said subject is a human.

Claim 18.   A kit for detecting or measuring the presence or amount of said truncated Tau protein in the brain of a subject, or for diagnosing Alzheimer's disease or another tauopathy in a subject, wherein said kit comprises the antibody-based molecule of claim 14.

Claim 19.   The use of any of claims 14, 16 or 17, or the medicament of claim 15, or the kit of claim 18, wherein said tauopathy is selected from the group comprising frontotemporal dementia, parkinsonism linked to chromosome 17 (FTDP-17), progressive supranuclear palsy, corticobasal degeneration, Pick's disease, progressive subcortical gliosis, tangle only dementia, diffuse neurofibrillary tangles with calcification, argyrophilic grain dementia, amyotrophic lateral

sclerosis parkinsonism-dementia complex, dementia pugilistica, Down syndrome, Gerstmann-Straussler-Scheinker disease, Hallerworden-Spatz disease, inclusion body myositis, Creutzfeld- Jakob disease, multiple system atropy, Niemann-Pick disease type C, prion protein cerebral amyloid angiopathy, subacute sclerosing panencephalitis, myotonic dystrophy, non-guanamian motor neuron disease with neurofibrillary tangles, postencephalitic parkinsonism, acute traumatic brain injury and chronic traumatic encephalopathy.
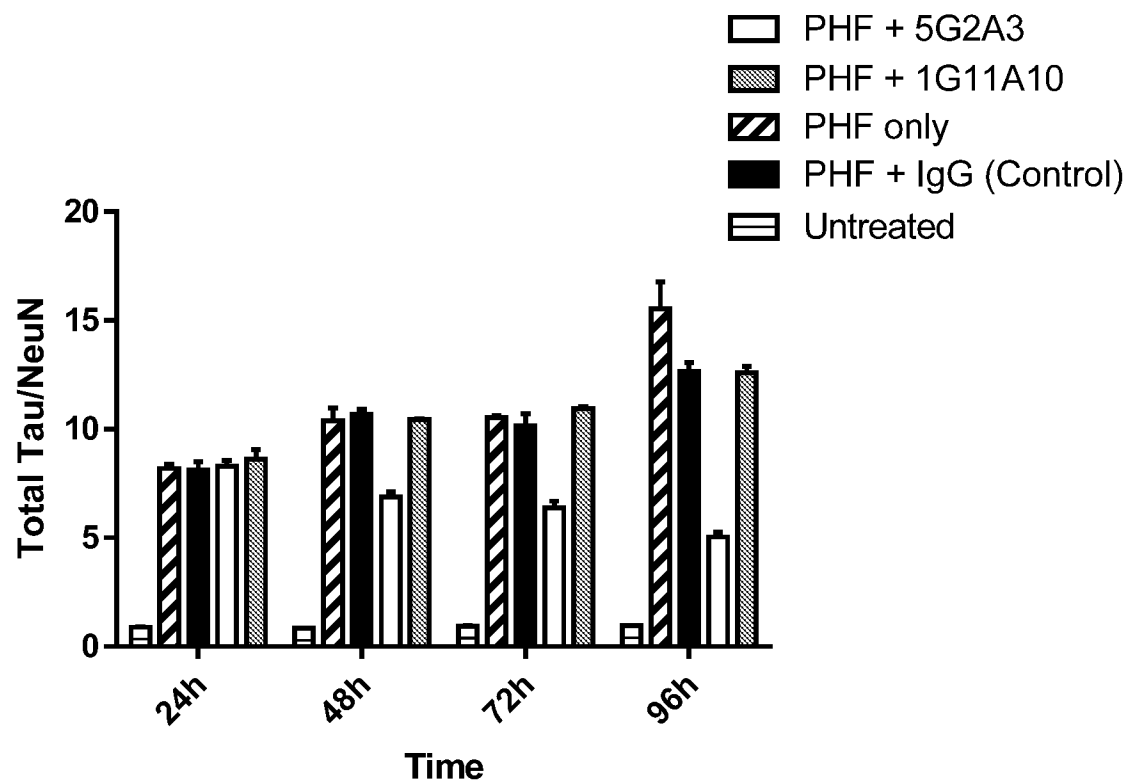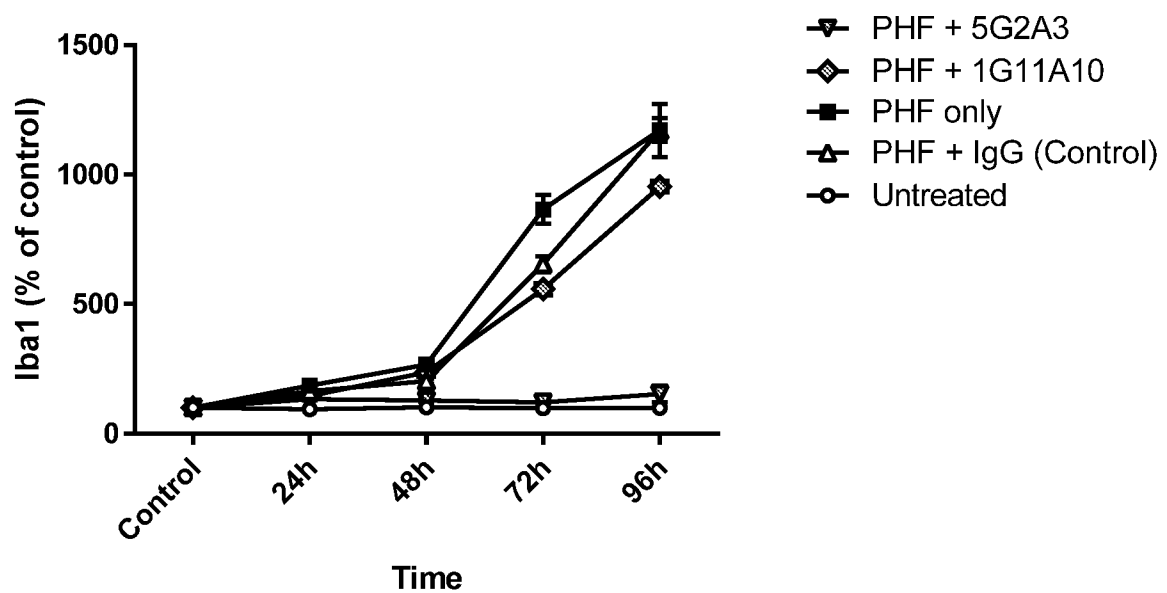
Figure 1A

Figure 1B

Antibody 5B3C11

Figure 1C

Antibody 5G2A3
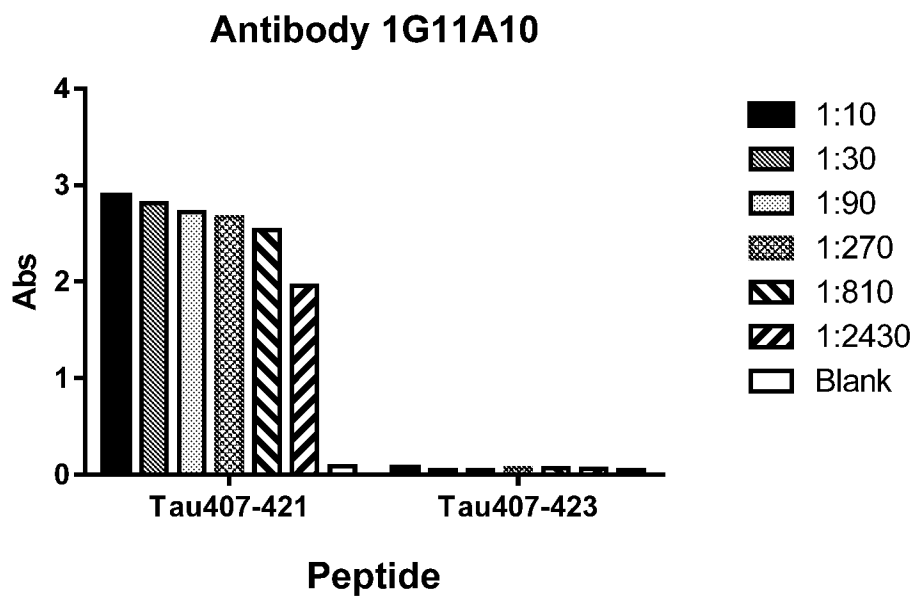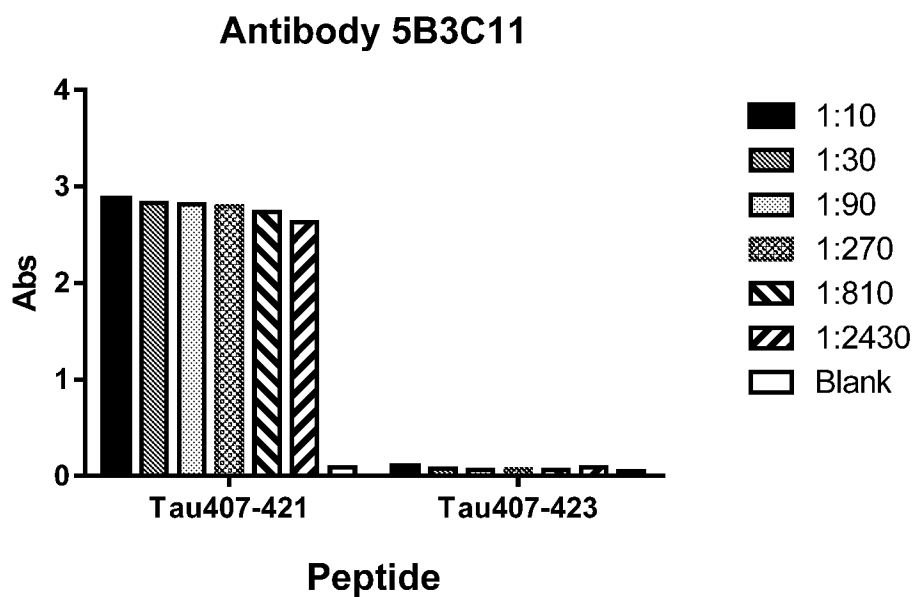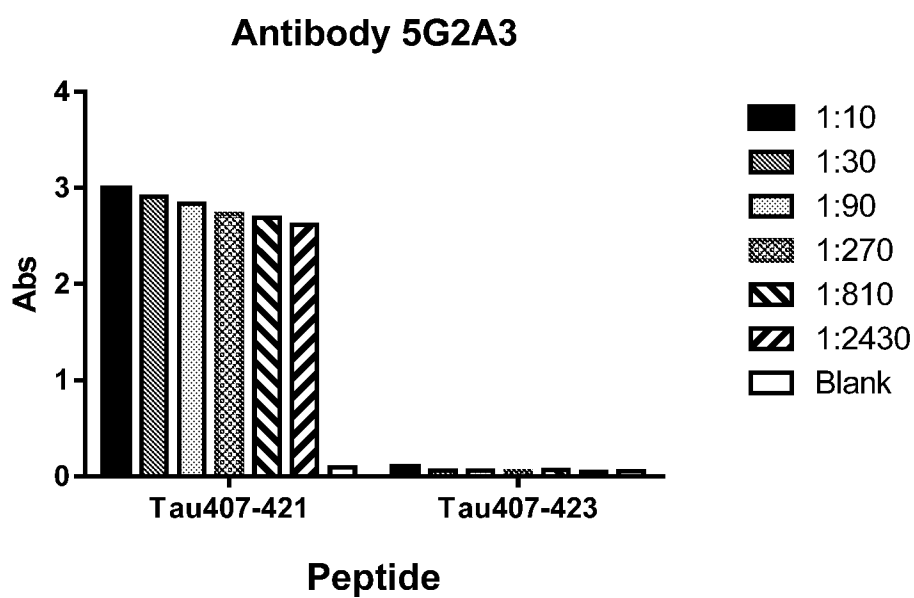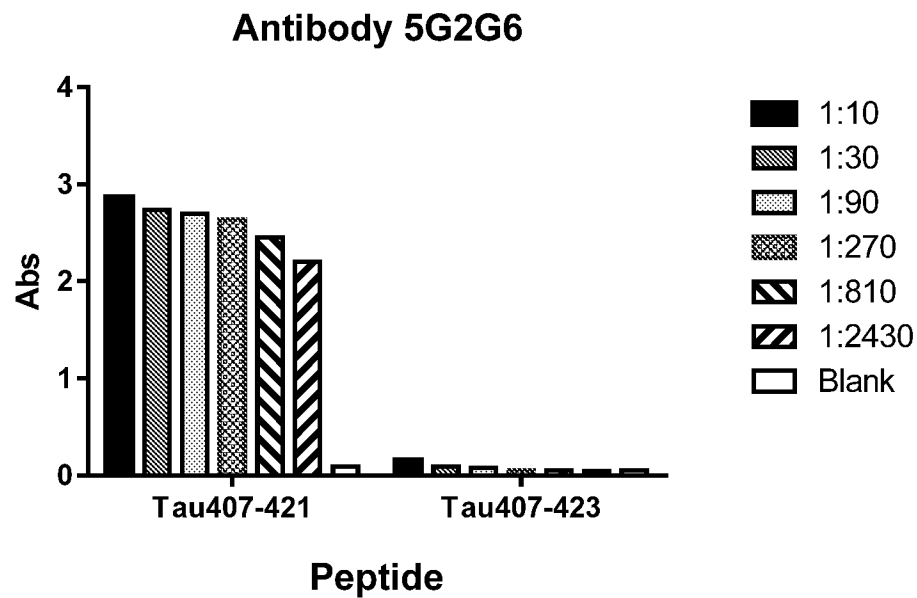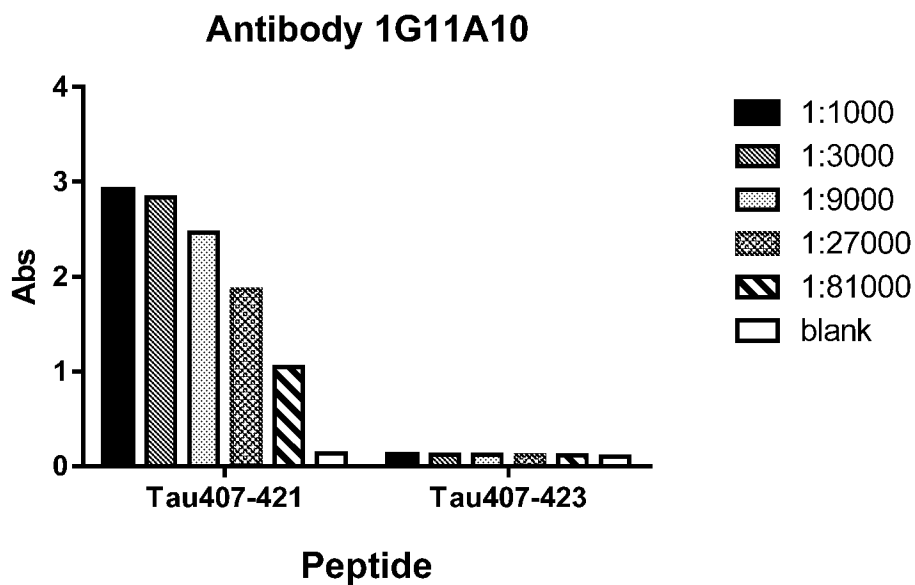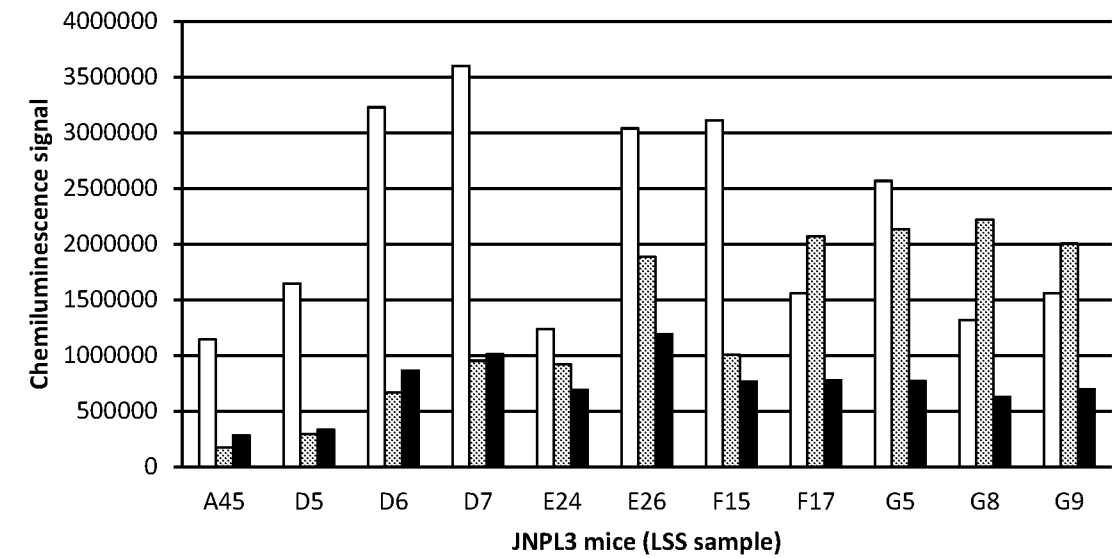

Figure 1D

Figure 1E

Figure 2A
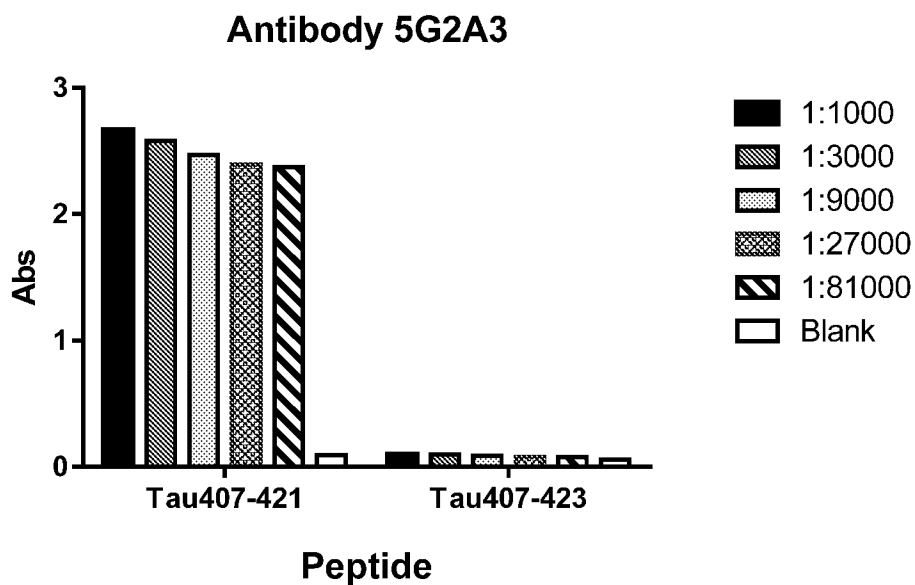
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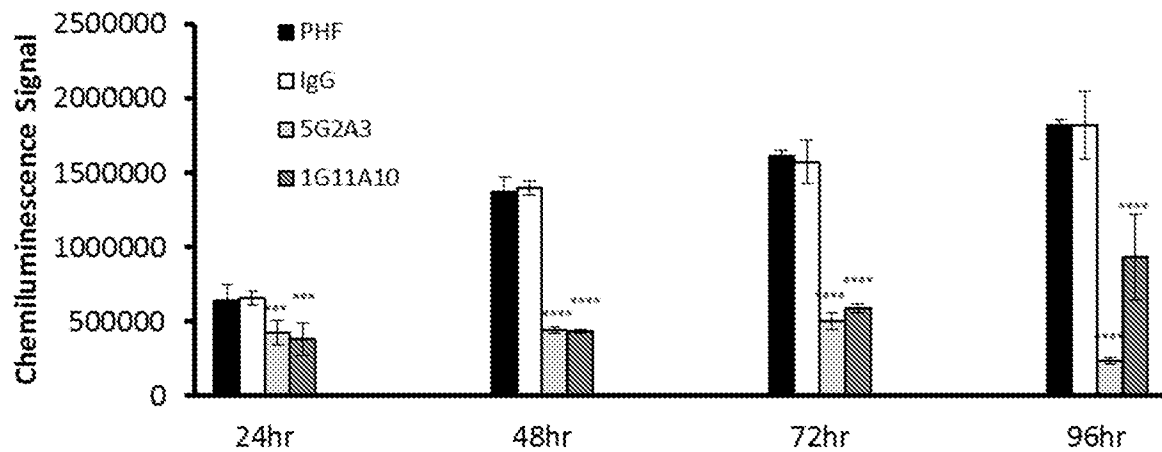
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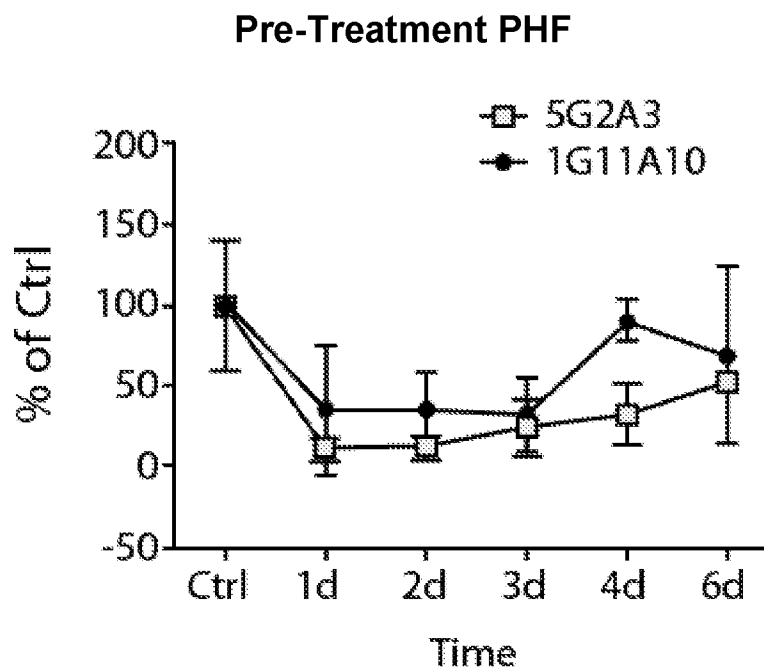
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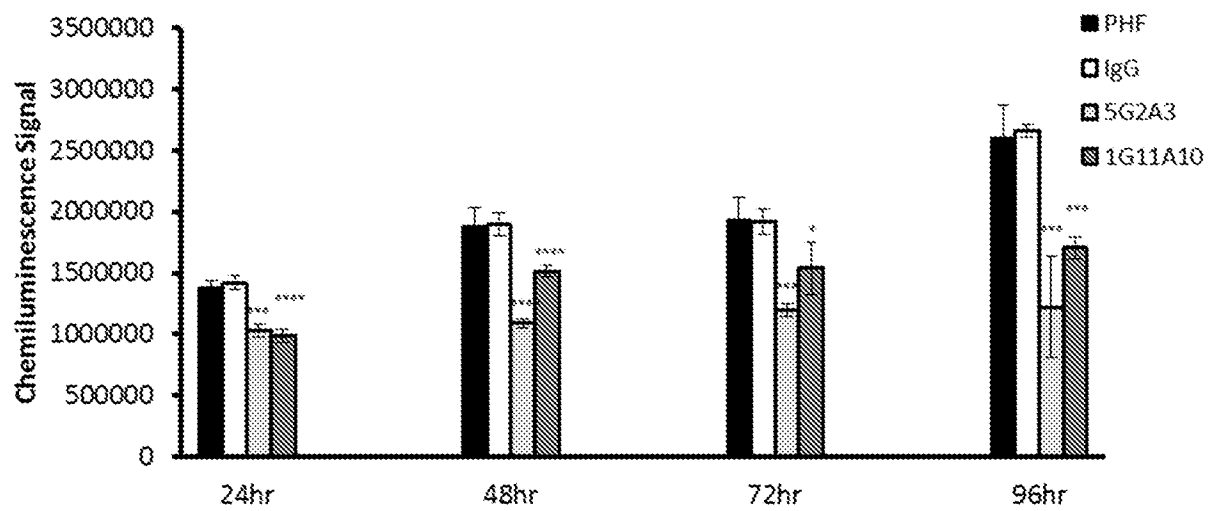
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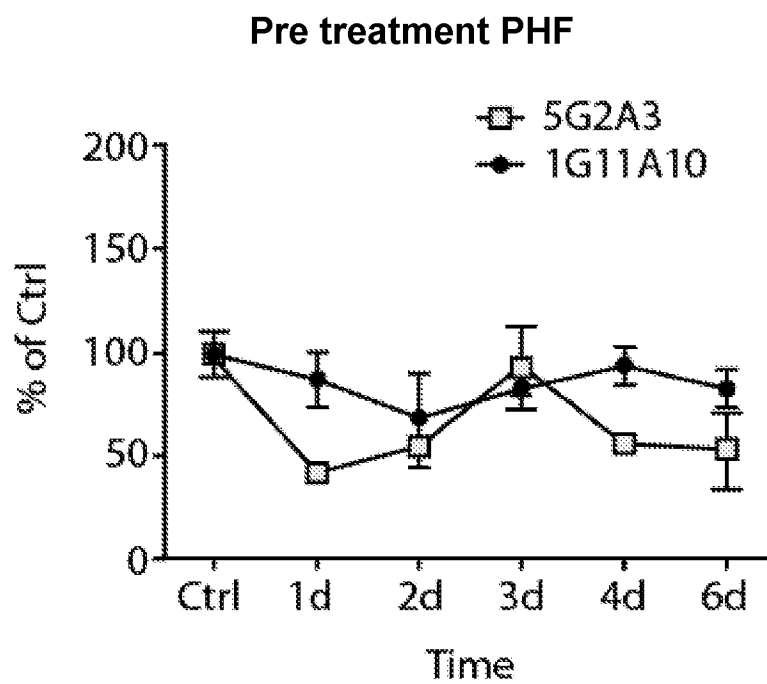
Figure 4B

Phospho Tau Levels In Mixed Cortical Culture

☐ PHF + 5G2A3
▨ PHF + 1G11A10
▱ PHF only
■ PHF + IgG (Control)
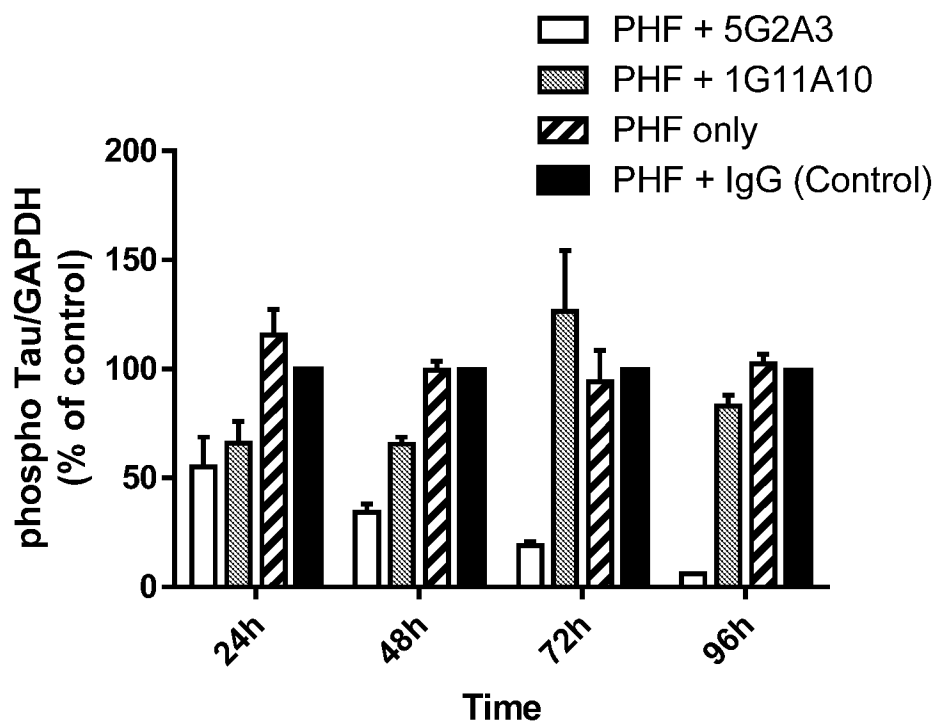
Figure 5A

Phospho Tau Levels In Primary Neuronal Culture

☐ PHF + 5G2A3
▨ PHF + 1G11A10
■ PHF + IgG (Control)
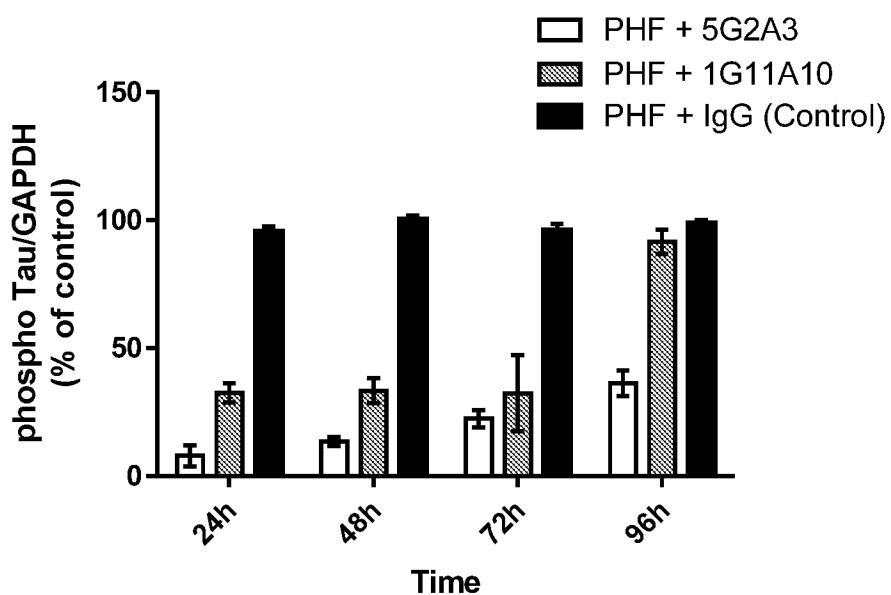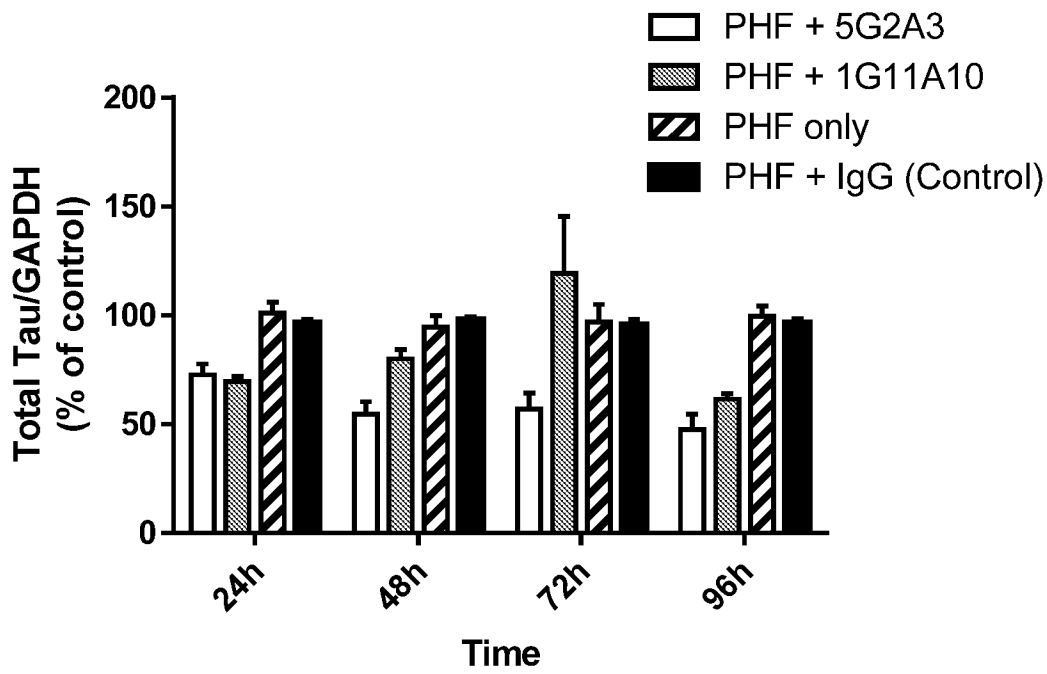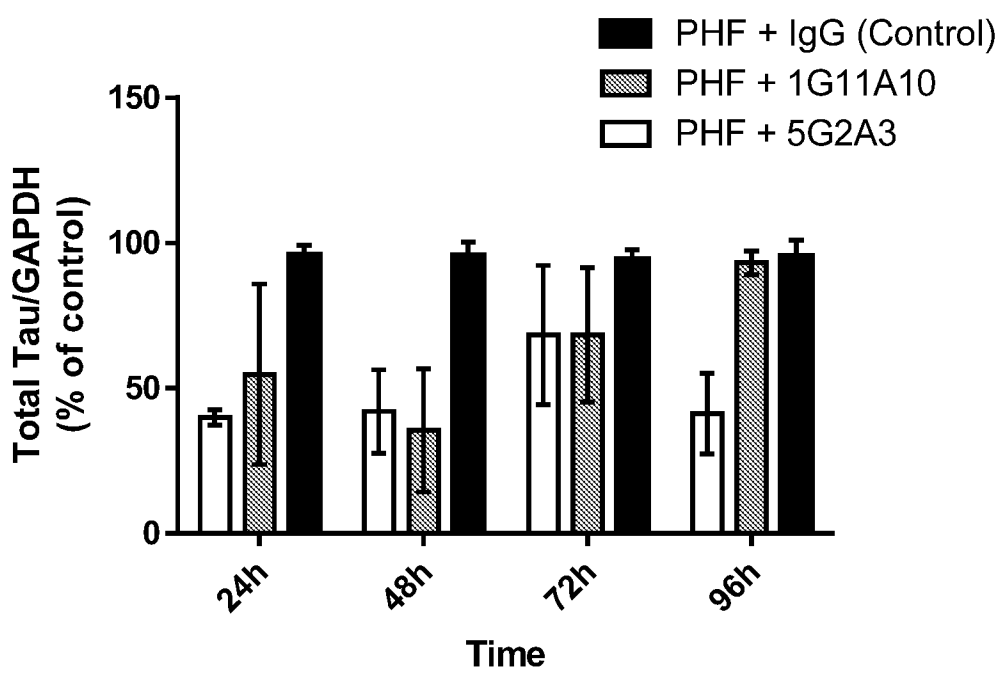
Figure 5B

Figure 6A

Figure 6B
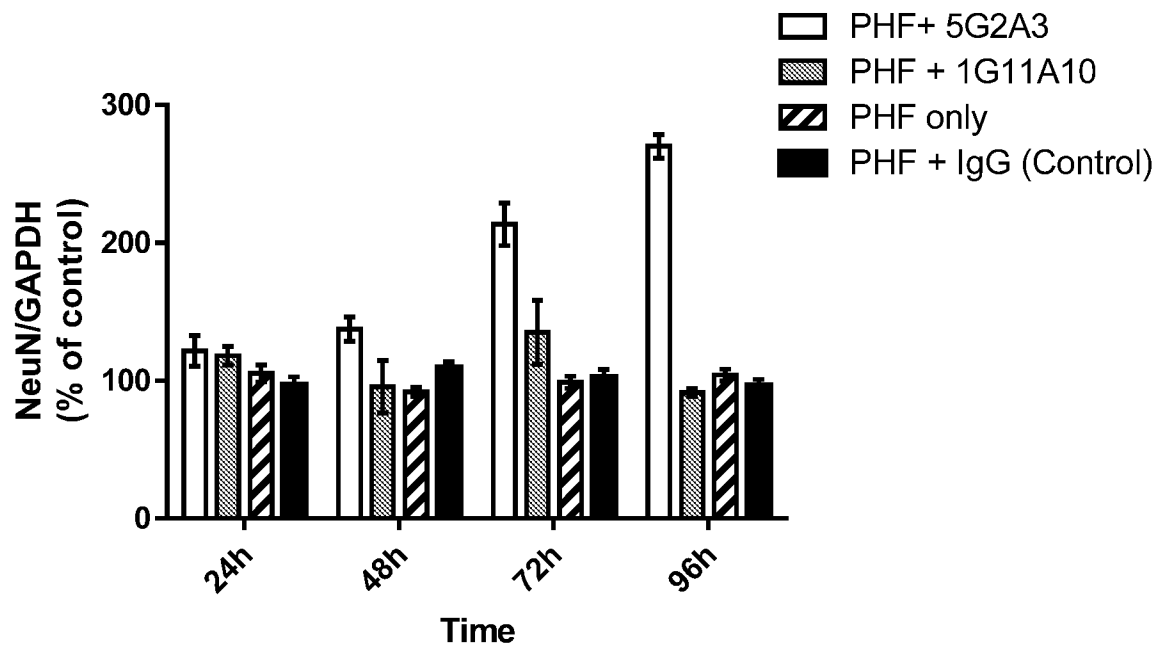
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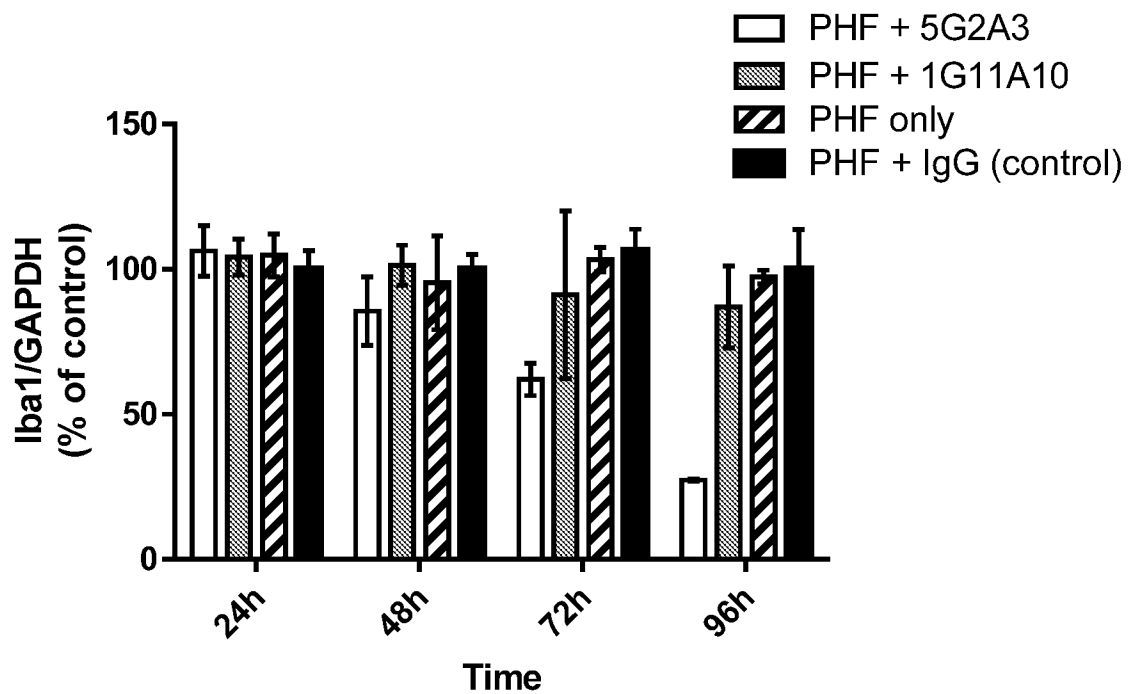
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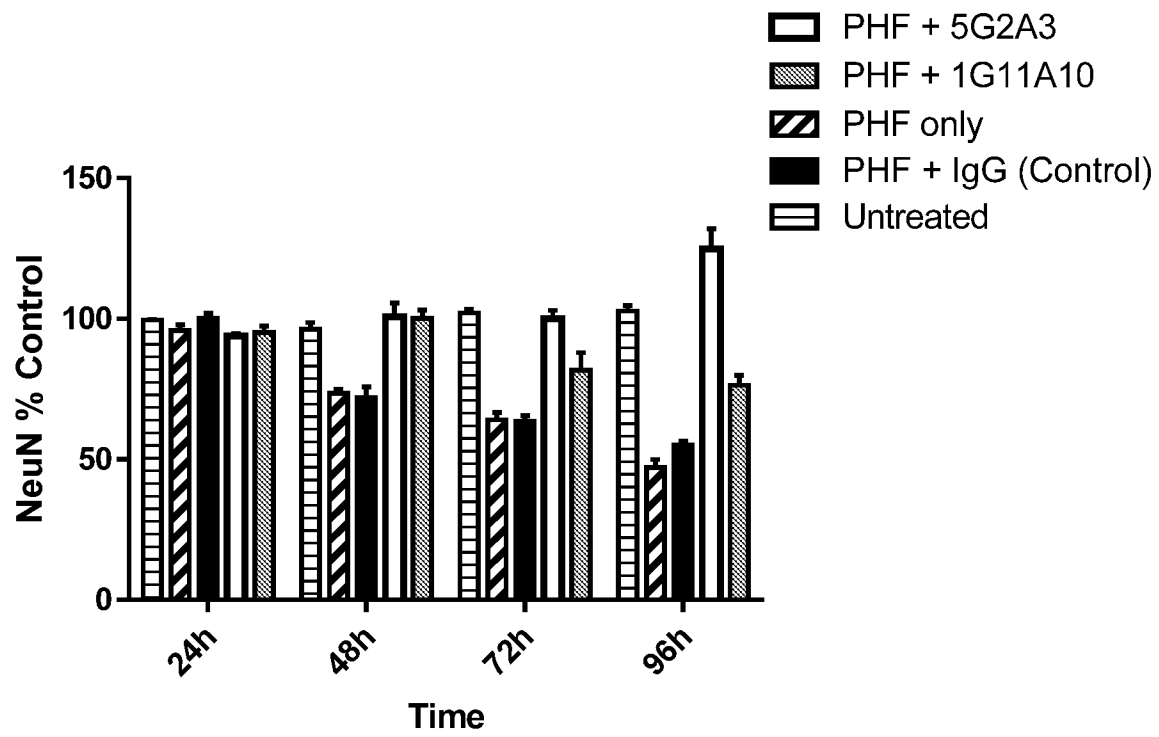
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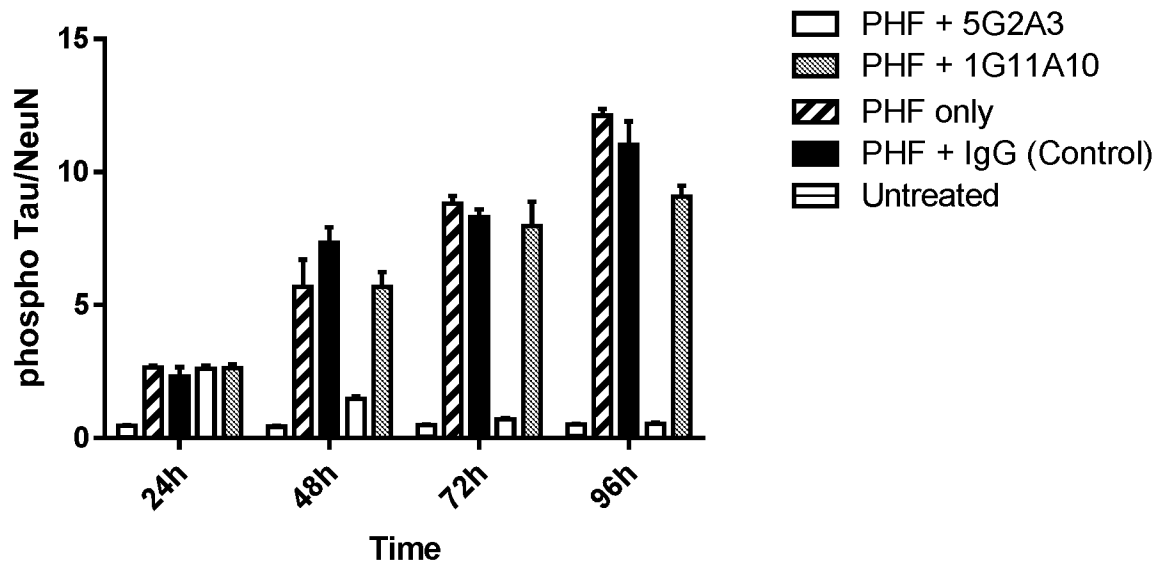
Figure 10

Figure 11

Figure 12

Figure 13A

Figure 13B

☐ 5G2A3

▨ 1G11A10

■ Tau C3

Figure 14