

HIGH AFFINITY ANTIBODIES TARGETING TAU PHOSPHORYLATED AT SERINE 413

Cross Reference to Related Applications

5 This application claims the benefit of priority to U.S. Provisional Application No. 63/044,291, filed June 25, 2020, the disclosure of which is incorporated by reference in its entirety.

FIELD

10 The present invention relates to high affinity antibodies or antigen binding fragments thereof that specifically bind to tau-pS413 (e.g., a human tau having the amino acid sequence of SEQ ID NO:1 that is phosphorylated at serine 413). The invention also relates to compositions, kits, methods, and uses involving the high affinity antibodies or antigen binding fragments disclosed herein.

BACKGROUND

15 Tau is a protein encoded by the MAPT gene, which is located on chromosome 17 (17q21) in the human genome. The tau protein is one of the microtubule-binding proteins abundantly expressed in the central nervous system. Tau has been found to be a major constituent protein in the paired helical filaments and straight filaments forming neurofibrillary tangles (NFT) in Alzheimer's disease (AD), one of the most prominent neurodegenerative
20 diseases, and its intracellular accumulation has been demonstrated in a variety of neuropathological conditions. The diseases caused by such intracellular accumulation of tau are collectively referred to as "tauopathies" (Tetsuaki Arai, "Shinkei Naika" (Japanese document), Vol.72, special number, (Suppl.6), 2010, pp.46-51). Tauopathies include neurodegenerative diseases such as AD, corticobasal degeneration (CBD) or corticobasal syndrome (CBS),
25 progressive supranuclear palsy, Pick's disease, argyrophilic grain dementia (argyrophilic grain disease), multiple system tauopathy with dementia (MSTD), chromosome 17-linked frontotemporal dementia with Parkinsonism (FTDP-17), neurofibrillary tangle dementia, diffuse neurofibrillary tangles with calcification (DNTC), white matter tauopathy with globular glial inclusions (WMT-GGI), frontotemporal lobar degeneration with tau-positive inclusions (FTLD-
30 tau). Tauopathies also include non-neurodegenerative diseases including: infectious diseases such as Economo's encephalitis sequela and subacute sclerosing panencephalitis; and trauma-

induced conditions such as boxer's encephalopathy (Tetsuaki Arai, "Shinkei Naika" (Japanese document), Vol.72, special number, (Suppl.6), 2010, pp.46-51).

Tau can be phosphorylated on a large number of amino acid residues, and phosphorylated tau has been believed to be the pathological tau species in tauopathies. While there are many known phosphorylation sites on tau and anti-tau antibodies with different specificities (e.g., targeting total tau, nonphosphorylated tau, or tau that is phosphorylated at various amino acid residues) in the art, it is still uncertain which phosphorylated tau species is the best target for treating tauopathies. Among the known anti-tau antibodies, some do not distinguish between pathological tau species (e.g., tau in the brain of AD patients) and normal tau (e.g., tau in the brain of healthy human beings), and others do not have a sufficiently high affinity and thus have to be administered at very high doses to reach an effective amount in the brain. Thus, there is unmet need to produce high affinity anti-tau antibodies that specifically target pathological tau species (e.g., tau-pS413).

SUMMARY OF THE INVENTION

The present disclosure provides high affinity antibodies or antigen binding fragments thereof that bind to human tau-pS413 (e.g., tau having the amino acid sequence of SEQ ID NO:1 that is phosphorylated at serine 413). Also provided herein are isolated nucleic acids and vectors comprising polynucleotide sequences encoding such high affinity antibodies or antigen binding fragments thereof, cells (e.g., host cells) comprising such isolated nucleic acids or vectors, compositions or kits comprising such high affinity antibodies or antigen binding fragments thereof, and methods or uses involving such high affinity antibodies or antigen binding fragments thereof.

In one aspect, provided herein is an antibody or antigen binding fragment thereof that binds to tau-pS413.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a heavy chain variable region complementarity determining region 1 (VH-CDR1) comprising the amino acid sequence of SEQ ID NO:41; a heavy chain variable region complementarity determining region 2 (VH-CDR2) comprising the amino acid sequence of SEQ ID NO:42; and a heavy chain variable region complementarity determining region 3 (VH-CDR3) comprising the amino acid sequence of SEQ ID NO:43; and a light chain variable region complementarity determining region 1 (VL-CDR1) comprising the amino acid sequence of SEQ ID NO:29; a light chain variable region complementarity determining region 2 (VL-CDR2)

comprising the amino acid sequence of SEQ ID NO:30; and a light chain variable region complementarity determining region 3 (VL-CDR3) comprising the amino acid sequence of SEQ ID NO:31.

5 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

10 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

15 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

20 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

25 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising

the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

5 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

10 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

15 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

20 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising

the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:86; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:87; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:88; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:83; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:84; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:85.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:92; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:93; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:94; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:89; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:90; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:91.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:98; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:99; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:100; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:95; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:96; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:97.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:104; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:105; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:106; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:101; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:102; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:103.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a heavy chain variable region (VH) comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a light chain variable region (VL) comprising the amino acid sequence of SEQ ID NO:32.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

5 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

10 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

15 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

25 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

30 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

5 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

10 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

15 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

25 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

30 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

5 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

10 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

15 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:32.

25 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:40.

30 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:28.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:20.

5 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:36.

10 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:40.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:28.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:20.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:32.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:36.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:40.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:28.

30 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:20.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:32.

5 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:36.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:40.

10 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:28.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL
15 having the amino acid sequence of SEQ ID NO:20.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:32.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:40.

25 In various embodiments of the antibody or antigen-binding fragment thereof that binds to tau-pS413 disclosed herein, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, 60, 61, 62, 63, 64, 65, 66, 67, or 68. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID
30 NO:59. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:60. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:61. In still another

embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:62. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:63. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:64. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:65. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:66. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:67. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:68.

In certain embodiments, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:57 or 58. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:57. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:58.

In some embodiments, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, 60, 61, 62, 63, 64, 65, 66, 67, or 68, and a light chain constant region having the amino acid sequence of SEQ ID NO:57 or 58. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:60, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:63, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:68, and a light chain constant region having the amino acid sequence of SEQ ID NO:58.

In certain embodiments, the antibody or antigen-binding fragment thereof comprises a light chain comprising the amino acid sequence of SEQ ID NO:71 and a heavy chain comprising the amino acid sequence of SEQ ID NO:72.

In some embodiments, the antibody or antigen-binding fragment thereof comprises a
5 light chain comprising the amino acid sequence of SEQ ID NO:73 and a heavy chain comprising the amino acid sequence of SEQ ID NO:74.

In other embodiments, the antibody or antigen-binding fragment thereof comprises a light chain comprising the amino acid sequence of SEQ ID NO:75 and a heavy chain comprising the amino acid sequence of SEQ ID NO:76.

10 In yet other embodiments, the antibody or antigen-binding fragment thereof consists of two light chains comprising the amino acid sequence of SEQ ID NO:71 and two heavy chains comprising the amino acid sequence of SEQ ID NO:72.

In still other embodiments, the antibody or antigen-binding fragment thereof consists of two light chains comprising the amino acid sequence of SEQ ID NO:73 and two heavy chains
15 comprising the amino acid sequence of SEQ ID NO:74.

In yet still other embodiments, the antibody or antigen-binding fragment thereof consists of two light chains comprising the amino acid sequence of SEQ ID NO:75 and two heavy chains comprising the amino acid sequence of SEQ ID NO:76.

In certain embodiments, the antibody or antigen-binding fragment thereof consists of two
20 light chains consisting of the amino acid sequence of SEQ ID NO:71 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:72.

In some embodiments, the antibody or antigen-binding fragment thereof consists of two light chains consisting of the amino acid sequence of SEQ ID NO:73 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:74.

25 In other embodiments, the antibody or antigen-binding fragment thereof consists of two light chains consisting of the amino acid sequence of SEQ ID NO:75 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:76.

In various embodiments of the antibody or antigen binding fragment thereof described herein, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant
30 (KD) of 1×10^{-8} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 9×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 8×10^{-9} M or less for tau-pS413. In yet other

embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 7×10^{-9} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 6×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 5×10^{-9} M or less for tau-pS413. In yet other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 4×10^{-9} M or less for tau-pS413. In still other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 3×10^{-9} M or less for tau-pS413. In yet still other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 2×10^{-9} M or less for tau-pS413. In some embodiments, the KD is measured by Surface Plasmon Resonance (SPR) assay with the antibody or antigen binding fragment thereof being immobilized. In one embodiment, the KD is measured by Biacore. In another embodiment, the KD is measured by KinExA.

In another aspect, provided is an isolated nucleic acid encoding various polypeptides disclosed herein.

In certain embodiments, the isolated nucleic acid encodes the VH of various antibodies or antigen binding fragments thereof disclosed herein. In some embodiments, the isolated nucleic acid encodes the VL of various antibodies or antigen binding fragments thereof disclosed herein. In other embodiments, the isolated nucleic acid encodes the VH and the VL of various antibodies or antigen binding fragments thereof disclosed herein.

In certain embodiments, the isolated nucleic acid encodes the heavy chain of various antibodies or antigen binding fragments thereof disclosed herein. In some embodiments, the isolated nucleic acid encodes the light chain of various antibodies or antigen binding fragments thereof disclosed herein. In other embodiments, the isolated nucleic acid encodes the heavy chain and the light chain of various antibodies or antigen binding fragments thereof disclosed herein.

In yet another aspect, provided is an expression vector comprising the various isolated nucleic acids disclosed herein.

In still another aspect, provided is a host cell comprising one or more of the various isolated nucleic acids or one of more of the various expression vectors disclosed herein. In some embodiments, the host cell comprises one of more of the various isolated nucleic acids disclosed herein. In other embodiments, the host cell comprises one of more of the various expression vectors disclosed herein.

In yet still another aspect, provided is a method of producing the antibody or antigen binding fragment thereof disclosed herein. In certain embodiments, the method of producing the antibody or antigen binding fragment thereof disclosed herein comprises expressing an isolated nucleic acid described herein under conditions wherein the antibody or antigen binding fragment thereof is expressed. In some embodiments, the method of producing the antibody or antigen binding fragment thereof disclosed herein comprises expressing an expression vector described herein under conditions wherein the antibody or antigen binding fragment thereof is expressed. In other embodiments, the method of producing the antibody or antigen binding fragment thereof disclosed herein comprises culturing the host cell comprising an isolated nucleic acid or an expression vector described herein under conditions wherein the antibody or antigen binding fragment thereof is expressed.

In another aspect, provided is a composition comprising the antibodies or antigen binding fragments thereof described herein and a pharmaceutically acceptable carrier.

In some embodiments, the composition further comprises an additional agent.

In particular embodiments, the additional agent is an agent effective to treat the same or different disorder as the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein are being used to treat. In some embodiments, the additional agent is an agent effective to mitigate one or more side effects of the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein. Exemplary additional agents include, but are not limited to: cholinesterase inhibitors (such as donepezil, galantamine, rivastigmine, and tacrine), NMDA receptor antagonists (such as memantine), amyloid beta peptide aggregation inhibitors, antioxidants, gamma-secretase modulators, nerve growth factor (NGF) mimics or NGF gene therapy, PPAR γ agonists, HMG-CoA reductase inhibitors (statins), amphotericins, calcium channel blockers, GABA receptor antagonists, glycogen synthase kinase inhibitors, intravenous immunoglobulin, muscarinic receptor agonists, nicotinic receptor modulators, active or passive amyloid beta peptide for immunization, phosphodiesterase inhibitors, serotonin receptor antagonists, anti-amyloid beta peptide antibodies, growth hormone, neurotrophic factor, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), neurotrophin-4/5, fibroblast growth factor (FGF)-2 and other FGFs, neurotrophin (NT)-3, erythropoietin (EPO), hepatocyte growth factor (HGF), epidermal growth factor (EGF), transforming growth factor (TGF)- α , TGF- β , vascular endothelial growth factor (VEGF), interleukin-1 receptor antagonist (IL-1ra), ciliary neurotrophic factor (CNTF), glial-derived neurotrophic factor (GDNF), neurturin, platelet-derived growth factor (PDGF), heregulin, neuregulin, artemin, persephin, interleukins,

glial cell line derived neurotrophic factor (GFR), granulocyte-colony stimulating factor (CSF), granulocyte-macrophage-CSF, netrins, cardiotrophin-1, hedgehogs, leukemia inhibitory factor (LIF), midkine, pleiotrophin, bone morphogenetic proteins (BMPs), netrins, saposins, semaphorins, stem cell factor (SCF), or a different anti-tau antibody.

5 In yet another aspect, provided is a kit comprising the antibodies or antigen binding fragments thereof described herein.

 In still another aspect, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of the antibodies or antigen binding fragments thereof described herein.

10 In some embodiments, the method further comprises administering to the subject an additional agent.

 In particular embodiments, the additional agent is an agent effective to treat the same or different disorder as the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein are being used to treat. In some embodiments, the additional agent is an agent effective to mitigate one or more side effects of the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein. Exemplary additional agents include, but are not limited to: cholinesterase inhibitors (such as donepezil, galantamine, rovastigmine, and tacrine), NMDA receptor antagonists (such as memantine), amyloid beta peptide aggregation inhibitors, antioxidants, gamma-secretase modulators, nerve growth factor (NGF) mimics or NGF gene therapy, PPAR γ agonists, HMG-CoA reductase inhibitors (statins), ampakines, calcium channel blockers, GABA receptor antagonists, glycogen synthase kinase inhibitors, intravenous immunoglobulin, muscarinic receptor agonists, nicotinic receptor modulators, active or passive amyloid beta peptide for immunization, phosphodiesterase inhibitors, serotonin receptor antagonists, anti-amyloid beta peptide antibodies, growth hormone, neurotrophic factor, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), neurotrophin-4/5, fibroblast growth factor (FGF)-2 and other FGFs, neurotrophin (NT)-3, erythropoietin (EPO), hepatocyte growth factor (HGF), epidermal growth factor (EGF), transforming growth factor (TGF)- α , TGF- β , vascular endothelial growth factor (VEGF), interleukin-1 receptor antagonist (IL-1ra), ciliary neurotrophic factor (CNTF), glial-derived neurotrophic factor (GDNF), neurturin, platelet-derived growth factor (PDGF), heregulin, neuregulin, artemin, persephin, interleukins, glial cell line derived neurotrophic factor (GFR), granulocyte-colony stimulating factor (CSF), granulocyte-macrophage-CSF, netrins, cardiotrophin-1, hedgehogs, leukemia inhibitory factor

(LIF), midline, pleiotrophin, bone morphogenetic proteins (BMPs), netrins, saposins, semaphorins, stem cell factor (SCF), or a different anti-tau antibody.

In some embodiments of the method, the tauopathy is a neurodegenerative disease, including but not limited to Alzheimer's disease (AD), corticobasal degeneration (CBD) or corticobasal syndrome (CBS), progressive supranuclear palsy, Pick's disease, argyrophilic grain dementia (argyrophilic grain disease), multiple system tauopathy with presenile dementia (MSTD), frontotemporal dementia and parkinsonism linked to chromosome 17 (FTDP-17), dementia with neurofibrillary tangles, diffuse neurofibrillary tangle with calcification (DNTC), white matter tauopathy with globular glial inclusions (WMT-GGI), or frontotemporal lobar degeneration with tau pathology (FTLD-tau). In one embodiment, the tauopathy is AD. In another embodiment, the tauopathy is CBD. In yet another embodiment, the tauopathy is progressive supranuclear palsy. In still another embodiment, the tauopathy is Pick's disease. In one embodiment, the tauopathy is argyrophilic grain dementia. In another embodiment, the tauopathy is MSTD. In yet another embodiment, the tauopathy is FTDP-17. In still another embodiment, the tauopathy is dementia with neurofibrillary tangles. In one embodiment, the tauopathy is DNTC. In another embodiment, the tauopathy is WMT-GGI. In yet another embodiment, the tauopathy is FTLD-tau.

In other embodiments of the method, the tauopathy is a non-neurodegenerative disease, including but not limited to infectious diseases, such as Economo's encephalitis sequela and subacute sclerosing panencephalitis, and trauma-induced conditions, such as boxer's encephalopathy. In one embodiment, the tauopathy is Economo's encephalitis sequela. In another embodiment, the tauopathy is subacute sclerosing panencephalitis. In yet another embodiment, the tauopathy is boxer's encephalopathy.

In yet still another aspect, provided is a method of decreasing the amount of tau-pS413 in the brain of a subject, comprising administering to the subject in need thereof an effective amount of the antibodies or antigen binding fragments thereof of described herein.

In some embodiments, the method further comprises administering to the subject an additional agent.

In particular embodiments, the additional agent is an agent effective to treat the same or different disorder as the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein are being used to treat. In some embodiments, the additional agent is an agent effective to mitigate one or more side effects of the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein. Exemplary additional agents include, but are not limited to:

cholinesterase inhibitors (such as donepezil, galantamine, rivastigmine, and tacrine), NMDA receptor antagonists (such as memantine), amyloid beta peptide aggregation inhibitors, antioxidants, gamma-secretase modulators, nerve growth factor (NGF) mimics or NGF gene therapy, PPAR γ agonists, HMG-CoA reductase inhibitors (statins), ampakines, calcium channel blockers, GABA receptor antagonists, glycogen synthase kinase inhibitors, intravenous immunoglobulin, muscarinic receptor agonists, nicotinic receptor modulators, active or passive amyloid beta peptide for immunization, phosphodiesterase inhibitors, serotonin receptor antagonists, anti-amyloid beta peptide antibodies, growth hormone, neurotrophic factor, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), neurotrophin-4/5, fibroblast growth factor (FGF)-2 and other FGFs, neurotrophin (NT)-3, erythropoietin (EPO), hepatocyte growth factor (HGF), epidermal growth factor (EGF), transforming growth factor (TGF)- α , TGF- β , vascular endothelial growth factor (VEGF), interleukin-1 receptor antagonist (IL-1ra), ciliary neurotrophic factor (CNTF), glial-derived neurotrophic factor (GDNF), neurturin, platelet-derived growth factor (PDGF), heregulin, neuregulin, artemin, persephin, interleukins, glial cell line derived neurotrophic factor (GFR), granulocyte-colony stimulating factor (CSF), granulocyte-macrophage-CSF, netrins, cardiotrophin-1, hedgehogs, leukemia inhibitory factor (LIF), midkine, pleiotrophin, bone morphogenetic proteins (BMPs), netrins, saposins, semaphorins, stem cell factor (SCF), or a different anti-tau antibody.

In yet additional embodiments, provided is the use of an antibody or antigen binding fragment thereof as disclosed herein to treat tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody or antigen binding fragment thereof as disclosed herein for the treatment of tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody or antigen binding fragment thereof as disclosed herein for the preparation of a medicament to treat tauopathy in a subject.

In some embodiments of the various uses described herein, the tauopathy is Alzheimer's disease, corticobasal degeneration, progressive supranuclear palsy, Pick's disease, argyrophilic grain dementia (argyrophilic grain disease), multiple system tauopathy with presenile dementia (MSTD), frontotemporal dementia and parkinsonism linked to chromosome 17 (FTDP-17), dementia with neurofibrillary tangles, diffuse neurofibrillary tangle with calcification (DNTC), white matter tauopathy with globular glial inclusions (WMT-GGI), frontotemporal lobar degeneration with tau pathology (FTLD-tau), Economo's encephalitis sequela, subacute sclerosing panencephalitis, or boxer's encephalopathy. In one embodiment, the tauopathy is AD.

In another embodiment, the tauopathy is CBD. In yet another embodiment, the tauopathy is progressive supranuclear palsy. In still another embodiment, the tauopathy is Pick's disease. In one embodiment, the tauopathy is argyrophilic grain dementia. In another embodiment, the tauopathy is MSTD. In yet another embodiment, the tauopathy is FTDP-17. In still another embodiment, the tauopathy is dementia with neurofibrillary tangles. In one embodiment, the tauopathy is DNTC. In another embodiment, the tauopathy is WMT-GGI. In yet another embodiment, the tauopathy is FTLD-tau. In one embodiment, the tauopathy is Economo's encephalitis sequela. In another embodiment, the tauopathy is subacute sclerosing panencephalitis. In yet another embodiment, the tauopathy is boxer's encephalopathy.

10 In yet a further embodiment, provided is an antibody or antigen binding fragment thereof as disclosed herein for use in a method for treating tauopathy in a subject.

In yet additional embodiments, provided is an antibody or antigen binding fragment thereof as disclosed herein for use in a method for diagnosing tauopathy in a subject.

BRIEF DESCRIPTION OF THE DRAWINGS

15 **FIGS. 1A and 1B** show amino acid sequence alignment of VH (**FIG. 1A**) and VL (**FIG. 1B**) of representative antibodies described herein. CDRs shown in these figures are defined by the Kabat numbering system.

FIGS. 2A-2F demonstrate that exemplary high affinity anti-tau-pS413 antibodies V8-AFM and V5-AFM bind specifically to tau-pS413 peptide. V8-AFM (e.g., V8-AFM-hIgG1-LALA-YTE, V8-AFM-hIgG1-LALA, V8-AFM-hIgG4-S228P) and V5-AFM (e.g., V5-AFM-hIgG4-S228P) bind to a peptide that has phosphorylated serine 413 (**FIG. 2A**) but do not bind to the same peptide without serine 413 phosphorylated (**FIG. 2B**) or peptides that are phosphorylated at other positions in the tau protein (**FIGS. 2C-2F**).

25 **FIGS. 3A and 3B** show competitive tau-pS413 immunoassay demonstrating binding of various exemplary anti-tau-pS413 antibodies to AD patient brain homogenates. **FIG. 3A** shows representative graph of curve fits with OD 450 nm as readouts and hIgGs as isotype control. **FIG. 3B** shows representative graph of curve fits with % of occupancy as readouts.

FIGS. 4A-4E demonstrate that immuno-depletion of P2 extract of AD brain homogenates with various exemplary anti-tau-pS413 antibodies prevents the induction of tau pathology in hiPSC neurons. **FIG. 4A** illustrates schematic representation of the neutralization protocol. **FIG. 4B and 4C** represent AlphaLISA[®] data used to confirm successful depletion of tau-pS413 and total tau, respectively. **FIG. 4D** shows representative images demonstrating

pathological MC1 tau (red spots) in neurons treated with P2 fraction (right panel) compared to no-treatment control (left panel). **FIG. 4E** represents the high-content image analysis of MC1 tau pathology in hiPSC neurons 5 days after seeding with immuno-depleted AD brain-derived P2 fractions with various concentration of exemplary anti-tau-pS413 antibodies or IgG control.

5 **FIG. 5** demonstrates dose response upon administration of an exemplary high affinity anti-tau-pS413 antibody V8-AFM-mIgG1 versus the mouse parental anti-tau-pS413 antibody pTa1505-mIgG1 on the reduction of tau pathology.

FIG. 6 shows that V6-AFM-hIgG1-LALA-YTE, which includes a K54E mutation in the VH, had improved production of the antibody molecule compared to V1-AFM-hIgG1-LALA-
10 YTE, which does not include the K54E mutation in its VH.

FIGS. 7A and 7B demonstrate ex vivo target engagement by V8-AFM-hIgG1-LALA-YTE in CSF samples from AD patients or non-AD humans. **FIG. 7A** shows A.U. readings in a tau-pS413 MSD assay for CSF samples from AD patients or non-AD humans in the presence of increased concentration of V8-AFM-hIgG1-LALA-YTE. **FIG. 7B** shows the percentage of
15 reduction of free tau-pS413 (unbound by V8-AFM-hIgG1-LALA-YTE) in CSF samples from AD patients or non-AD humans.

DETAILED DESCRIPTION

Abbreviations

Throughout the detailed description and examples of the invention the following
20 abbreviations will be used:

ADCC	Antibody-dependent cellular cytotoxicity
CDC	Complement-dependent cytotoxicity
CDR	Complementarity determining region in the immunoglobulin variable regions
25 CHO	Chinese hamster ovary
EC50	concentration resulting in 50% efficacy or binding
ELISA	Enzyme-linked immunosorbent assay
FR	Antibody framework region: the immunoglobulin variable regions excluding the CDR regions.
30 IC50	concentration resulting in 50% inhibition
IgG	Immunoglobulin G

	Kabat	An immunoglobulin alignment and numbering system pioneered by Elvin A. Kabat ((1991) Sequences of Proteins of Immunological Interest, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, Md.)
	mAb	Monoclonal antibody
5	PK	Pharmacokinetics
	V region	The segment of IgG chains which is variable in sequence between different antibodies. It extends to Kabat residue 109 in the light chain and 113 in the heavy chain.
	VH	Immunoglobulin heavy chain variable region
10	VL	Immunoglobulin light chain variable region

Definitions

So that the invention may be more readily understood, certain technical and scientific terms are specifically defined below. Unless specifically defined elsewhere in this document, all other technical and scientific terms used herein have the meaning commonly understood by one of ordinary skill in the art to which this invention belongs.

As used herein, including the appended claims, the singular forms of words such as "a," "an," and "the," include their corresponding plural references unless the context clearly dictates otherwise. Similarly, the plural forms of words include their corresponding singular references unless the context clearly indicates otherwise.

The term "tau protein," when used in the context of human species, refers to six isoforms of human tau protein having the amino acid sequences defined in SEQ ID NOs:1 to 6, i.e., 4R2N (defined in SEQ ID NO:1), 4R1N (defined in SEQ ID NO:2), 4R0N (defined in SEQ ID NO:3), 3R2N (defined in SEQ ID NO:4), 3R1N (defined in SEQ ID NO:5), and 3R0N (defined in SEQ ID NO:6), as well as gene variants thereof. The tau protein according to the present invention also encompasses proteins having similarities or identities of 80% or more to the amino acid sequence of the human tau protein defined in SEQ ID NO:1 in accordance with the BLAST method (with default conditions of PBLAST provided by NCBI) and their isoforms. Such tau proteins also include tau derived from non-human species, such as chimpanzees, macaques, horses, pigs, dogs, mice, rabbits, and rats. It is possible to produce a therapeutic or prophylactic agent targeted to tau derived from such a non-human animal for the purpose of improving the cognitive function of the target animal.

The term "tau peptide" used herein means a peptide including a part of the amino acid sequence of a tau protein. The position of the tau peptide derived from a tau protein should not

be limited. The length of the tau peptide should also not be limited, but should preferably have an amino acid length of four or more, particularly six or more, more particularly eight or more.

The term “tau” used herein means a tau protein or a tau peptide collectively.

In the context of the present invention, the position of an amino acid residue in a tau protein or a tau peptide is indicated by an amino acid number, which is identified based on the amino acid sequence defined in SEQ ID NO:1 for clarification. For example, “serine 413,” “Ser413,” or “S413” refers to the amino acid residue corresponding to Ser413 of SEQ ID NO:1, including the serine residue at amino acid position 413 of SEQ ID NO:1 (4R2N), amino acid position 384 of SEQ ID NO:2 (4R1N), amino acid position 355 of SEQ ID NO:3 (4R0N), amino acid position 382 of SEQ ID NO:4 (3R2N), amino acid position 353 of SEQ ID NO:5 (3R1N), or amino acid position 324 of SEQ ID NO:6 (3R0N). Correspondence of the positions of amino acid residues between tau isoforms is shown in **TABLE 1** below.

TABLE 1. Isoforms of human tau protein

Isoform	4R2N	4R1N	4R0N	3R2N	3R1N	3R0N
Sequence	SEQ ID NO:1	SEQ ID NO:2	SEQ ID NO:3	SEQ ID NO:4	SEQ ID NO:5	SEQ ID NO:6
Amino acid residue	Amino acid position/number					
Asn	410	381	352	379	350	321
Val	411	382	353	380	351	322
Ser	412	383	354	381	352	323
Ser	413	384	355	382	353	324
Thr	414	385	356	383	354	325
Gly	415	386	357	384	355	326
Ser	416	387	358	385	356	327
Ile	417	388	359	386	357	328
Asp	418	389	360	387	358	329
Met	419	390	361	388	359	330
Val	420	391	362	389	360	331
Asp	421	392	363	390	361	332

While **TABLE 1** shows the positions of amino acid residues of the recited isoforms corresponding to positions 410 to 421 of the amino acid sequence defined in SEQ ID NO:1, correspondence of the positions of amino acid residues in other regions can easily be recognized based on, e.g., FIGS. 1A and 1B of WO 2018/254390, the entirety of which disclosure is incorporated by reference herein. In order to know corresponding positions of amino acids in isoforms or homologues, a person skilled in the art would be able to carry out analysis using pairwise sequence alignment such as Needleman-Wunsch method or Smith-Waterman method, or multiple sequence alignment such as ClustalW method or PRRP method. As an example of analysis of corresponding positions, FIGS. 1A and 1B of WO 2018/254390 show an alignment of the amino acid sequences of the six human isoforms (indicated with one letter codes) based on ClustalW. These figures indicate that the structure surrounding the amino acid residue corresponding to Ser413 of the amino acid sequence defined in SEQ ID NO:1 is conserved among the six isoforms, and also help to identify the amino acids corresponding to one another.

The statement that an amino acid residue is “phosphorylated” as used herein means that a phosphate group is ester-linked to the side chain of the amino acid residue. Typical amino acid residues that may be phosphorylated include serine (Ser), threonine (Thr), and tyrosine (Tyr).

The term “tau-pS413,” “tau-PS413,” “tau-pSer413,” “pS413-tau,” “PS413-tau,” or “pSer413-tau,” as used herein, refers to a tau protein or peptide that is phosphorylated at the amino acid residue corresponding to Ser413 of SEQ ID NO:1, including the serine residue at amino acid position 413 of SEQ ID NO:1 (4R2N), amino acid position 384 of SEQ ID NO:2 (4R1N), amino acid position 355 of SEQ ID NO:3 (4R0N), amino acid position 382 of SEQ ID NO:4 (3R2N), amino acid position 353 of SEQ ID NO:5 (3R1N), or amino acid position 324 of SEQ ID NO:6 (3R0N). In some embodiments, tau-pS413 is phosphorylated only at S413. In certain embodiments, tau-pS413 is phosphorylated at S413 and one or more additional amino acid residues.

“Anti-tau-pS413 antibody” as used herein refers to an antibody that specifically binds to a tau-pS413 protein or a tau-pS413 peptide.

Each of the term “V1-AFM,” “V2-AFM,” “V3-AFM,” “V4-AFM,” “V5-AFM,” “V6-AFM,” “V7-AFM,” or “V8-AFM,” as used herein, refers to an affinity matured variant of HmzTa1505-hIgG4-S228P as described herein, comprising the defined VH and VL as described in **TABLE 4**, with SEQ ID NOs disclosed in **TABLES 5** and **6**. Each term encompasses antibodies with any one of known heavy chain constant region (e.g., IgG1, IgG1-LALA, IgG1-

LALA-YTE, IgG2, IgG3, IgG4, IgG4-S228P, etc.) or variant thereof and any one of known light chain constant region (e.g., lambda or kappa) or variant thereof.

The terms "binds" or "binding" refer to an interaction between molecules including, for example, to form a complex. Interactions can be, for example, non-covalent interactions including hydrogen bonds, ionic bonds, hydrophobic interactions, and/or van der Waals interactions. A complex can also include the binding of two or more molecules held together by covalent or non-covalent bonds, interactions, or forces. The strength of the total non-covalent interactions between a single antigen-binding site on an antibody and a single epitope of a target molecule, such as tau, is the "affinity" of the antibody or functional fragment for that epitope or target. Unless indicated otherwise, as used herein, "binding affinity" refers to intrinsic binding affinity which reflects a 1:1 interaction between members of a binding pair (e.g., antibody and antigen). The ratio of dissociation rate (k_{off}) to association rate (k_{on}) of an antibody to a monovalent antigen ($k_{\text{off}}/k_{\text{on}}$) is the "dissociation constant" (or "equilibrium dissociation constant" as used interchangeably) K_D , which is inversely related to affinity. The lower the K_D value, the higher the affinity of the antibody. The value of K_D varies for different complexes of antibody and antigen and depends on both k_{on} and k_{off} . The dissociation constant K_D for an antibody provided herein can be determined using any method provided herein or any other method well known to those skilled in the art, such as surface plasmon resonance (SPR) assay, including but not limited to Biacore and KinExA. The affinity at one binding site does not always reflect the true strength of the interaction between an antibody and an antigen. When complex antigens containing multiple, repeating antigenic determinants, such as a polyvalent antigen, come in contact with antibodies containing multiple binding sites, the interaction of antibody with antigen at one site will increase the probability of a reaction at a second site. The strength of such multiple interactions between a multivalent antibody and antigen is called the "avidity." The avidity of an antibody can be a better measure of its binding capacity than is the affinity of its individual binding sites. For example, high avidity can compensate for low affinity as is sometimes found for pentameric IgM antibodies, which can have a lower affinity than IgG, but the high avidity of IgM, resulting from its multivalence, enables it to bind antigen effectively. Unless indicated otherwise, the term "affinity" or "binding affinity" as used herein refers to monovalent (1:1) interaction between an anti-tau-pS413 antibody and a tau-pS413 protein or peptide. The K_D can be measured using SPR with either the anti-tau-pS413 antibody or tau-pS413 immobilized. The K_D values disclosed in this specification are measured with the anti-tau-pS413 antibody immobilized.

The terms "antibodies that specifically bind to tau-pS413," "antibodies that specifically bind to a tau-pS413 protein or peptide," and analogous terms are used interchangeably herein and refer to antibodies that specifically bind to a tau-pS413 polypeptide, such as a tau-pS413 protein or peptide (e.g., human tau-pS413 such as a human tau-pS413 protein or peptide). An antibody that specifically binds to tau-pS413 (e.g., human tau-pS413) may be cross-reactive with tau-pS413 derived from another species (e.g., cynomolgus tau-pS413). In certain embodiments, an antibody that specifically binds to tau-pS413 does not cross-react with other [tau] proteins or peptides, such as a tau protein or peptide that is not phosphorylated at S413 or a tau protein or peptide that is phosphorylated at another amino acid residue other than S413. An antibody that specifically binds to tau-pS413 can be identified, for example, by immunoassays, Biacore, or other techniques known to those of skill in the art. An antibody binds specifically to tau-pS413 when it binds to tau-pS413 with higher affinity than to any cross-reactive protein or peptide as determined using experimental techniques, such as radioimmunoassays (MA) and enzyme linked immunosorbent assays (ELISAs). Typically, a specific reaction will be at least twice background signal or noise and may be more than 10 times background. See, e.g., Fundamental Immunology 332-36 (Paul ed., 2d ed. 1989) for a discussion regarding antibody specificity. With regard to the binding of an antibody to a target molecule, the term "specific binding," "specifically binds to," or "is specific for" a particular polypeptide or an epitope on a particular polypeptide target means binding that is measurably different from a non-specific interaction. Specific binding can be measured, for example, by determining binding of a molecule compared to binding of a control molecule, which generally is a molecule of similar structure that does not have binding activity. For example, specific binding to a target can be determined by competition with a control molecule that is similar to the target, for example, an excess of non-labeled target. In this case, specific binding is indicated if the binding of the labeled target to a probe is competitively inhibited by excess unlabeled target.

"Administering" or "administration," as it applies to an animal, human, subject, cell, tissue, organ, or biological fluid, refers to contact of an exogenous pharmaceutical, therapeutic, diagnostic agent, or composition to the animal, human, subject, cell, tissue, organ, or biological fluid.

The term "subject" includes any organism, preferably an animal, more preferably a mammal (e.g., human, rat, mouse, dog, cat, or rabbit). In a preferred embodiment, the term "subjects" refers to a human.

The term "antibody," "immunoglobulin," or "Ig" is used interchangeably herein, and is used in the broadest sense and specifically encompasses, for example, individual monoclonal antibodies (including neutralizing antibodies, full length or intact monoclonal antibodies), antibody compositions with polyepitopic or monoepitopic specificity, polyclonal or monovalent antibodies, multivalent antibodies, multispecific antibodies (e.g., bispecific antibodies so long as they exhibit the desired biological activity), formed from at least two intact antibodies, single chain antibodies, and fragments of the antibodies, as described below. An antibody can be human, humanized, chimeric and/or affinity matured, as well as an antibody from other species, for example, mouse and rabbit, etc. Antibodies also include, but are not limited to, synthetic antibodies, recombinantly produced antibodies, camelized antibodies, intrabodies, anti-idiotypic (anti-Id) antibodies, and functional fragments (e.g., antigen-binding fragments thereof) of any of the above, which refers to a portion of an antibody heavy or light chain polypeptide that retains some or all of the binding activity of the antibody from which the fragment was derived. Non-limiting examples of functional fragments (e.g., antigen-binding fragments thereof) include single-chain Fvs (scFv) (e.g., including monospecific, bispecific, etc.), Fab fragments, F(ab') fragments, F(ab)₂ fragments, F(ab')₂ fragments, disulfide-linked Fvs (dsFv), Fd fragments, Fv fragments, diabody, triabody, tetrabody, and minibody. In particular, antibodies provided herein include immunoglobulin molecules and immunologically active portions of immunoglobulin molecules, for example, antigen-binding domains or molecules that contain an antigen-binding site that binds to a tau-pS413 protein or peptide (e.g., one or more CDRs of an anti-tau-pS413 antibody). Such antibody fragments can be found in, for example, Harlow and Lane, *Antibodies: A Laboratory Manual* (1989); Mol. Biology and Biotechnology: A Comprehensive Desk Reference (Myers ed., 1995); Huston et al., 1993, *Cell Biophysics* 22:189-224; Pluckthun and Skerra, 1989, *Meth. Enzymol.* 178:497-515; and Day, *Advanced Immunochemistry* (2d ed. 1990). The antibodies provided herein can be of any class (e.g., IgG, IgE, IgM, IgD, and IgA) or any subclass (e.g., IgG1, IgG2, IgG3, IgG4, IgA1, and IgA2) of immunoglobulin molecule.

A "Fab fragment" is comprised of one light chain and the C_H1 and variable regions of one heavy chain. The heavy chain of a Fab molecule cannot form a disulfide bond with another heavy chain molecule. An "Fab fragment" can be the product of papain cleavage of an antibody.

An "Fc" region contains two heavy chain fragments comprising the C_H1 and C_H2 domains of an antibody. The two heavy chain fragments are held together by two or more disulfide bonds and by hydrophobic interactions of the C_H3 domains.

A "Fab' fragment" contains one light chain and a portion or fragment of one heavy chain that contains the V_H domain and the C_{H1} domain and also the region between the C_{H1} and C_{H2} domains, such that an interchain disulfide bond can be formed between the two heavy chains of two Fab' fragments to form a F(ab')₂ molecule.

5 A "F(ab')₂ fragment" contains two light chains and two heavy chains containing a portion of the constant region between the C_{H1} and C_{H2} domains, such that an interchain disulfide bond is formed between the two heavy chains. A F(ab')₂ fragment thus is composed of two Fab' fragments that are held together by a disulfide bond between the two heavy chains. An "F(ab')₂ fragment" can be the product of pepsin cleavage of an antibody.

10 An "Fv fragment" or "Fv region" comprises the variable regions from both the heavy and light chains, but lacks the constant regions.

The term "monoclonal antibody," as used herein, refers to a population of substantially homogeneous antibodies, *i.e.*, the antibody molecules comprising the population are identical in amino acid sequence except for possible naturally occurring mutations that may be present in
15 minor amounts. In contrast, conventional (polyclonal) antibody preparations typically include a multitude of different antibodies having different amino acid sequences in their variable domains that are often specific for different epitopes. The modifier "monoclonal" indicates the character of the antibody as being obtained from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. For
20 example, the monoclonal antibodies to be used in accordance with the present invention may be made by the hybridoma method first described by Kohler *et al.* (1975) *Nature* 256: 495, or may be made by recombinant DNA methods (*see, e.g.*, U.S. Pat. No. 4,816,567). The "monoclonal antibodies" may also be isolated from phage antibody libraries using the techniques described in Clackson *et al.* (1991) *Nature* 352: 624-628 and Marks *et al.* (1991) *J. Mol. Biol.* 222: 581-597,
25 for example. *See also* Presta (2005) *J. Allergy Clin. Immunol.* 116:731.

As used herein, the term "humanized antibody" refers to forms of antibodies that contain sequences from both human and non-human (*e.g.*, murine, rat) antibodies. In general, the humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the hypervariable loops correspond to those of a non-
30 human immunoglobulin, and all or substantially all of the framework (FR) regions are those of a human immunoglobulin sequence. The humanized antibody may optionally comprise at least a portion of a human immunoglobulin constant region (Fc).

In general, the basic antibody structural unit comprises a tetramer. Each tetramer includes two identical pairs of polypeptide chains, each pair having one "light" (about 25 kDa) and one "heavy" chain (about 50-70 kDa). The amino-terminal portion of each chain includes a variable region of about 100 to 110 or more amino acids primarily responsible for antigen
5 recognition. The carboxy-terminal portion of the heavy chain may define a constant region primarily responsible for effector function.

"Effector functions" refer to those biological activities attributable to the Fc region of an antibody, which vary with the antibody isotype. Examples of antibody effector functions include: Clq binding and complement dependent cytotoxicity (CDC); Fc receptor
10 binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (e.g. B cell receptor); and B cell activation.

Typically, human light chains are classified as kappa and lambda light chains. Furthermore, human heavy chains are typically classified as mu, delta, gamma, alpha, or epsilon, and define the antibody's isotype as IgM, IgD, IgG, IgA, and IgE, respectively. Within light and
15 heavy chains, the variable and constant regions are joined by a "J" region of about 12 or more amino acids, with the heavy chain also including a "D" region of about 10 more amino acids. See generally, Fundamental Immunology Ch. 7 (Paul, W., ed., 2nd ed. Raven Press, N.Y. (1989).

"Variable region," "variable domain," or "V region" or "V chain" as used herein means the segment of IgG chains which is variable in sequence between different antibodies. A
20 "variable region" of an antibody refers to the variable region of the antibody light chain or the variable region of the antibody heavy chain, either alone or in combination. The variable region of the heavy chain may be referred to as "VH." The variable region of the light chain may be referred to as "VL." Typically, the variable regions of both the heavy and light chains comprise three hypervariable regions, also called complementarity determining regions (CDRs), which are
25 located within relatively conserved framework regions (FR). The CDRs are usually aligned by the framework regions, enabling binding to a specific epitope. In general, from N-terminal to C-terminal, both light and heavy chains variable domains comprise FR1, CDR1, FR2, CDR2, FR3, CDR3, and FR4. The assignment of amino acids to each domain is, generally, in accordance with the definitions of Sequences of Proteins of Immunological Interest, Kabat, *et al.*; National
30 Institutes of Health, Bethesda, Md.; 5th ed.; NIH Publ. No. 91-3242 (1991) ("Kabat 1"); Kabat (1978) Adv. Prot. Chem. 32:1-75 ("Kabat 2"); Kabat, *et al.*, (1977) J. Biol. Chem. 252:6609-6616 ("Kabat 3"); Chothia, *et al.*, (1987) J Mol. Biol. 196:901-917 ("Chothia 1") or Chothia, *et al.*, (1989) Nature 342:878-883 ("Chothia 2").

A “CDR” refers to one of three hypervariable regions (H1, H2, or H3) within the non-framework region of the antibody V_H β -sheet framework, or one of three hypervariable regions (L1, L2, or L3) within the non-framework region of the antibody V_L β -sheet framework. Accordingly, CDRs are variable region sequences interspersed within the framework region sequences. CDR regions are well known to those skilled in the art and have been defined by, for example, Kabat as the regions of most hypervariability within the antibody variable domains (see Kabat 1-3, *supra*). CDR region sequences also have been defined structurally by Chothia as those residues that are not part of the conserved β -sheet framework, and thus are able to adapt to a different conformation (see Chothia 1-2, *supra*). Both Kabat and Chothia methodologies for defining CDR sequences within antibody variable regions are well recognized in the art. CDR region sequences have also been defined by AbM, Contact, and IMGT. The positions of CDRs within a canonical antibody variable region have been determined by comparison of numerous structures (Al-Lazikani et al., 1997, J. Mol. Biol. 273:927-48; Morea et al., 2000, Methods 20:267-79). Because the number of residues within a hypervariable region varies in different antibodies, additional residues relative to the canonical positions are conventionally numbered with a, b, c and so forth next to the residue number in the canonical variable region numbering scheme (Al-Lazikani et al., *supra*). Such nomenclature is similarly well known to those skilled in the art. Correspondence between the numbering system, including, for example, the Kabat numbering and the IMGT unique numbering system, is well known to one skilled in the art and shown below in **TABLE 2**. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system. In yet still other embodiments, the CDRs are as defined by any numbering system that is known to those skilled in the art.

TABLE 2. Correspondence of Amino Acid Positions Between CDR Numbering Systems

	IMGT	Kabat	AbM	Chothia	Contact
V _H CDR1	27-38	31-35	26-35	26-32	30-35
V _H CDR2	56-65	50-65	50-58	52-56	47-58
V _H CDR3	105-117	95-102	95-102	95-102	93-101

V _L CDR1	27-38	24-34	24-34	24-34	30-36
V _L CDR2	56-65	50-56	50-56	50-56	46-55
V _L CDR3	105-117	89-97	89-97	89-97	89-96

"Conservatively modified variants" or "conservative substitution" refers to substitutions of amino acids in a protein with other amino acids having similar characteristics (e.g. charge, side-chain size, hydrophobicity/hydrophilicity, backbone conformation and rigidity, etc.), such that the changes can frequently be made without altering the biological activity of the protein.

- 5 Those of skill in this art recognize that, in general, single amino acid substitutions in non-essential regions of a polypeptide do not substantially alter biological activity (*see, e.g., Watson et al. (1987) Molecular Biology of the Gene*, The Benjamin/Cummings Pub. Co., p. 224 (4th Ed.)). In addition, substitutions of structurally or functionally similar amino acids are less likely to disrupt biological activity. Exemplary conservative substitutions are set forth in **TABLE 3**.

10

TABLE 3. Exemplary Conservative Amino Acid Substitutions

Original residue	Conservative substitution
Ala (A)	Gly; Ser
Arg (R)	Lys; His
Asn (N)	Gln; His
Asp (D)	Glu; Asn
Cys (C)	Ser; Ala
Gln (Q)	Asn
Glu (E)	Asp; Gln
Gly (G)	Ala
His (H)	Asn; Gln
Ile (I)	Leu; Val
Leu (L)	Ile; Val
Lys (K)	Arg; His
Met (M)	Leu; Ile; Tyr
Phe (F)	Tyr; Met; Leu
Pro (P)	Ala
Ser (S)	Thr

Original residue	Conservative substitution
Thr (T)	Ser
Trp (W)	Tyr; Phe
Tyr (Y)	Trp; Phe
Val (V)	Ile; Leu

The term "epitope," as used herein, is defined in the context of a molecular interaction between an "antigen binding molecule," such as an antibody (Ab), and its corresponding "antigen" (Ag). Generally, "epitope" refers to the area or region on an Ag to which an Ab specifically binds, i.e. the area or region in physical contact with the Ab. Physical contact may be defined through distance criteria (e.g. a distance cut-off of 4 Å) for atoms in the Ab and Ag molecules. Epitopes may be linear epitopes or conformational epitopes. Linear epitopes are formed by a continuous sequence of amino acids in a protein. Conformational epitopes are formed of amino acids that are discontinuous in the protein sequence, but which are brought together upon folding of the protein into its three-dimensional structure. Induced epitopes are formed when the three-dimensional structure of the protein is in an altered conformation, such as following activation or binding of another protein or ligand.

"Isolated nucleic acid" means a DNA or RNA polynucleotide of genomic, mRNA, cDNA, or synthetic origin or some combination thereof which is not associated with all or a portion of a polynucleotide in which the isolated polynucleotide is found in nature, or is linked to a polynucleotide to which it is not linked in nature. Isolated nucleic acid molecules "comprising" specified nucleic acid sequences may include, in addition to the specified sequences, coding sequences for up to ten or even up to twenty or more other proteins or portions or fragments thereof, or may include operably linked regulatory sequences that control expression of the coding region of the recited nucleic acid sequences, and/or may include vector sequences or non-coding sequences.

The phrase "control sequences" refers to DNA sequences necessary for the expression of an operably linked coding sequence in a particular host organism. The control sequences that are suitable for prokaryotes, for example, include a promoter, optionally an operator sequence, and a ribosome binding site. Eukaryotic cells are known to use promoters, polyadenylation signals, and enhancers.

A nucleic acid is "operably linked" when it is placed into a functional relationship with another nucleic acid sequence. For example, DNA for a presequence or secretory leader is

operably linked to DNA for a polypeptide if it is expressed as a preprotein that participates in the secretion of the polypeptide; a promoter or enhancer is operably linked to a coding sequence if it affects the transcription of the sequence; or a ribosome binding site is operably linked to a coding sequence if it is positioned so as to facilitate translation. Generally, "operably linked" means that the DNA sequences being linked are contiguous, and, in the case of a secretory leader, contiguous and in reading phase. However, enhancers do not have to be contiguous. Linking is accomplished by ligation at convenient restriction sites. If such sites do not exist, the synthetic oligonucleotide adaptors or linkers are used in accordance with conventional practice.

As used herein, the expressions "cell," "host cell," "cell line," and "cell culture" are used interchangeably and all such designations include progeny.

"Treat" or "treatment" means to administer an agent, such as a composition containing any of the antibodies or antigen binding fragments thereof of the present invention, internally or externally to a subject or patient having one or more disease symptoms, or being suspected of having a disease, for which the agent has therapeutic activity. Typically, the agent is administered in an amount effective to alleviate one or more disease symptoms in the treated subject or population, whether by inducing the regression of or inhibiting, delaying or slowing the progression of such symptom(s) by any clinically measurable degree. The amount of an agent that is effective to alleviate any particular disease symptom may vary according to factors such as the disease state, age, and weight of the patient, and the ability of the drug to elicit a desired response in the subject. Whether a disease symptom has been alleviated can be assessed by any clinical measurement typically used by physicians or other skilled healthcare providers to assess the severity or progression status of that symptom. The term further includes a postponement of development of the symptoms associated with a disorder and/or a reduction in the severity of the symptoms of such disorder. The terms further include ameliorating existing uncontrolled or unwanted symptoms, preventing additional symptoms, and ameliorating or preventing the underlying causes of such symptoms. Thus, the terms denote that a beneficial result has been conferred on a vertebrate subject with a disorder, disease or symptom, or with the potential to develop such a disorder, disease or symptom.

Tau-pS413

Tau is a protein encoded by the MAPT gene, which is located on chromosome 17 (17q21) in the human genome. The tau protein is one of the microtubule-binding proteins abundantly expressed in the central nervous system. The tau protein has been found to be a major constituent protein in the paired helical filaments and straight filaments forming NFT in

AD, one of the most prominent neurodegenerative diseases, and its intracellular accumulation has been demonstrated in a variety of neuropathological conditions. The diseases caused by such intracellular accumulation of tau are collectively referred to as “tauopathies” (Tetsuaki Arai, “Shinkei Naika” (Japanese document), Vol.72, special number, (Suppl.6), 2010, pp.46-51).

- 5 Tauopathies include neurodegenerative diseases such as Alzheimer’s disease (AD), corticobasal degeneration (CBD) or corticobasal syndrome (CBS), progressive supranuclear palsy, Pick’s disease, argyrophilic grain dementia (argyrophilic grain disease), multiple system tauopathy with dementia (MSTD), chromosome 17-linked frontotemporal dementia with Parkinsonism (FTDP-17), neurofibrillary tangle dementia, diffuse neurofibrillary tangles with calcification (DNTEC),
 10 white matter tauopathy with globular glial inclusions (WMT-GGI), frontotemporal lobar degeneration with tau-positive inclusions (FTLD-tau). Tauopathies also include non-neurodegenerative diseases including: infectious diseases such as Economo’s encephalitis sequela and subacute sclerosing panencephalitis; and trauma-induced conditions such as boxer’s encephalopathy (Tetsuaki Arai, “Shinkei Naika” (Japanese document), Vol.72, special number,
 15 (Suppl.6), 2010, pp.46-51).

- The MAPT gene has been identified as consisting of 13 exons disposed on the genome, which can be expressed as multiple different protein isoforms via alternative splicing (Tetsuaki Arai, “Shinkei Naika” (Japanese document), Vol.72, special number, (Suppl.6), 2010, pp.46-51). The structure of tau comprises an N-terminal acidic domain containing 0-2 repetitive sequences
 20 (N) of 29 amino acids depended on alternative splicing of exon 2 and exon 3 (N0-N2), an intermediate domain rich in proline, and a C-terminal microtubule-binding domain (encoded by exons 9 to 12) containing 3 (3R) or 4 (4R) repetitive sequences (R) that contribute to microtubule binding (Alistair Burns et al. (Edit.), Dementia, 3rd Edition, 2005, CRC Press, pp.408-464; Tetsuaki Arai, “Shinkei Naika” (Japanese document), Vol.72, special number,
 25 (Suppl.6), 2010, pp.46-51). Therefore, human tau has six representative isoforms: 3R0N (352 amino acids), 3R1N (381 amino acids), 3R2N (410 amino acids), 4R0N (383 amino acids), 4R1N (412 amino acids), and 4R2N (441 amino acids), depending on the number of 29 amino acid repetitive sequences (N) and microtubule-binding repetitive sequences (R) that it contains. In order to unambiguously identify the position of an amino acid residue in any of these tau
 30 isoforms, the amino acid numbers (1 to 441) of the longest isoform, i.e., 4R2N (defined in SEQ ID NO:1), are used as a reference herein. For example, “Ser413” refers to the serine residue at the 413th amino acid position in 4R2N (defined in SEQ ID NO:1), which corresponds to the serine at the 384th amino acid position in 4R1N (defined in SEQ ID NO:2), the 355th amino acid

position in 4R0N (defined in SEQ ID NO:3), the 382nd amino acid position in 3R2N (defined in SEQ ID NO:4), the 353rd amino acid position in 3R1N (defined in SEQ ID NO:5), and the 324th amino acid position in 3R0N (defined in SEQ ID NO:6).

In addition, tau accumulated in neurodegenerative diseases is characterized by being highly modified via phosphorylation. In patients exhibiting mild cognitive impairment, a correlation is observed between the level of phosphorylated tau in the spinal fluid and the degree of pituitary atrophy, suggesting phosphorylated tau as a highly reliable biomarker for neurodegeneration in patients with tauopathy (Wendy Noble et al., Expert Opinion on Drug Discovery, 2011, Vol.6, No.8, pp.797-810). However, there are a large number of sites which can be phosphorylated in tau, while virtually no information exists regarding which antibodies for which phosphorylation sites are effective to treat tauopathy.

Furthermore, when using an antibody as an active compound for a therapeutic or prophylactic agent, it is necessary to consider the amount of the antibody to be administered in patients, in order to avoid side effects and minimize problems such as, immunogenicity, manufacture capacity, and medical cost. This is especially important in relation to doses for chronic diseases or genetic diseases. In addition, while the brain is the target organ to be treated in cognitive disorders such as AD, systemic administration by intravenous or subcutaneous routes is generally thought to result in a low migration rate of antibodies from the blood to the brain, due to the presence of the blood-brain barrier. Accordingly, there is a significant problem that antibodies used for treatment of cognitive disorders are expected to require high dosages, compared to treatment for diseases involving other organs. Thus, against the backdrop of these challenges, it is particularly unexpected and surprising for the inventors to have generated high affinity anti-tau-pS413 antibodies that can achieve sufficient therapeutic effects without affecting non-pathological tau or having to be administered at very high dosages.

High Affinity Anti-tau-pS413 Antibodies or Antigen Binding Fragments Thereof

Previous disclosures of anti-tau-pS413 antibodies include WO 2013/180238 and WO 2018/254390, the entirety of which disclosures are incorporated by reference herein. Distinct from the prior disclosures, the present invention provides higher affinity anti-tau-pS413 antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof. These high affinity anti-tau-pS413 antibodies or antigen binding fragments thereof show increased binding potency compared to previously disclosed anti-tau-pS413 antibodies (e.g., at least 10- to 40-fold increase) to recombinant tau-pS413 protein or peptide, tau transgenic mouse brains, AD patients' brain

homogenates, and AD patients' CSF samples. Such high affinity antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof can also effectively prevent the development of tau pathology in hu-iPSC neurons induced by seeding of AD brain homogenates.

- 5 In this disclosure, optimized (e.g., higher affinity) versions of the previously disclosed anti-tau-pS413 antibodies were obtained by affinity maturation to improve potency or by structure-based modeling to identify one or more amino acid mutations (e.g., K54E or K54D) that lowers pI (isoelectric point), improves affinity, and increases production of the antibody molecule. In some embodiments, the optimized (e.g., higher affinity) anti-tau-pS413 antibodies
- 10 can be obtained by affinity maturation. In certain embodiments, the optimized (e.g., higher affinity) anti-tau-pS413 antibodies can be obtained by structure-based modeling to identify one or more amino acid mutations (e.g., K54E or K54D) that lowers pI, improves affinity, and increases production of the antibody molecule. In other embodiments, the optimized (e.g.,
- 15 higher affinity) anti-tau-pS413 antibodies can be obtained by affinity maturation and structure-based modeling to identify one or more amino acid mutations (e.g., K54E or K54D) that lowers pI, improves affinity, and increases production of the antibody molecule. In additional embodiments, the heavy chain constant region of the optimized (e.g., higher affinity) anti-tau-pS413 antibodies is switched from IgG4-S228P isotype to IgG1-LALA to improve colloidal stability and lower viscosity while maintaining reduced Fc effector function. In further
- 20 embodiments, a half-life extension YTE mutation is integrated into the Fc region to increase half-life of the optimized (e.g., higher affinity) anti-tau-pS413 antibodies. In yet other embodiments, the heavy chain constant region of the optimized (e.g., higher affinity) anti-tau-pS413 antibodies is switched from IgG4-S228P isotype to IgG1-LALA and a half-life extension YTE mutation is integrated into the Fc region. In a preferred embodiment, an optimized (e.g.,
- 25 higher affinity) anti-tau-pS413 antibody (e.g., V1-AFM-hIgG1-LALA-YTE, V2-AFM-hIgG1-LALA-YTE, V3-AFM-hIgG1-LALA-YTE, V4-AFM-hIgG1-LALA-YTE, V5-AFM-hIgG1-LALA-YTE, V6-AFM-hIgG1-LALA-YTE, V7-AFM-hIgG1-LALA-YTE, or V8-AFM-hIgG1-LALA-YTE) is obtained by 1) affinity maturation, 2) structure-based modeling to identify a mutation (e.g., K54E or K54D) that lowers pI, improves affinity, and increases production of the
- 30 antibody molecule, 3) switching isotype to IgG1-LALA to improve colloidal stability and lower viscosity while maintaining reduced Fc effector function, and 4) integrating a YTE mutation into the Fc region to extend half-life.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of
5 SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising
10 the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a
15 VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In still another embodiment, the antibody or antigen binding fragment thereof that binds
20 to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-
30 CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising

the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

5 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

10 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

25 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid
5 sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the
10 amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a
15 VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds
20 to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

25 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID
30 NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the

amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

5 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

10 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

15 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

20 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

25 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid
5 sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:86; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:87; and a VH-CDR3 comprising
10 the amino acid sequence of SEQ ID NO:88; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:83; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:84; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:85.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:92; a VH-
15 CDR2 comprising the amino acid sequence of SEQ ID NO:93; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:94; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:89; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:90; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:91.

In another embodiment, the antibody or antigen binding fragment thereof that binds to
20 tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:98; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:99; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:100; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:95; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:96; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:97.

25 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:104; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:105; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:106; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:101; a VL-CDR2 comprising the amino acid sequence of SEQ ID
30 NO:102; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:103.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino

acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM
5 numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino
10 acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia
15 numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL
20 comprising the amino acid sequence of SEQ ID NO:40. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact
25 numbering system.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28. In some embodiments, the CDRs are as
30 defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia

numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL

comprising the amino acid sequence of SEQ ID NO:40. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

25 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM

numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL

comprising the amino acid sequence of SEQ ID NO:28. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40. In some embodiments, the CDRs are as defined by the Kabat numbering system. In other embodiments, the CDRs are as defined by the IMGT numbering system. In yet other embodiments, the CDRs are as defined by the AbM numbering system. In still other embodiments, the CDRs are as defined by the Chothia numbering system. In yet other embodiments, the CDRs are as defined by the Contact numbering system.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

25 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:44, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:48, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:52, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

5 In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

10 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

15 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

20 In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:28.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:20.

25 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:32.

30 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:24, and a VL having at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:40.

5 In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:32.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having
10 the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:40.

In still another embodiment, the antibody or antigen binding fragment thereof that binds
15 to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:28.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:20.

20 In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL
25 having the amino acid sequence of SEQ ID NO:36.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:40.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-
30 pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:28.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:20.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:32.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:36.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:40.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:28.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:20.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:32.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:36.

In another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:28.

In still another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:20.

In one embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:32.

In another embodiment, the antibody or antigen binding fragment thereof that binds to
5 tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of SEQ ID NO:40.

10 In various embodiments of the antibody or antigen-binding fragment thereof that binds to tau-pS413 disclosed herein, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, 60, 61, 62, 63, 64, 65, 66, 67, or 68. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID
15 NO:59. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:60. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:61. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain
20 constant region having the amino acid sequence of SEQ ID NO:62. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:63. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:64. In yet another embodiment, the antibody or antigen-
25 binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:65. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:66. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ
30 ID NO:67. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:68. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is

present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In certain embodiments, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:57 or 58.

- 5 In one embodiment, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:57. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a light chain constant region having the amino acid sequence of SEQ ID NO:58.

- 10 In some embodiments, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, 60, 61, 62, 63, 64, 65, 66, 67, or 68, and a light chain constant region having the amino acid sequence of SEQ ID NO:57 or 58. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, and a light chain constant region having the amino acid sequence of
- 15 SEQ ID NO:57. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:60, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:61, and a light chain
- 20 constant region having the amino acid sequence of SEQ ID NO:57. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:62, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid
- 25 sequence of SEQ ID NO:63, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:64, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a
- 30 heavy chain constant region having the amino acid sequence of SEQ ID NO:65, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:66, and a light chain constant region

having the amino acid sequence of SEQ ID NO:57. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:67, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In another embodiment, the antibody or antigen-binding fragment thereof

5 further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:68, and a light chain constant region having the amino acid sequence of SEQ ID NO:57. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:59, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In still another embodiment,

10 the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:60, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:61, and a light chain constant region having the amino acid sequence of

15 SEQ ID NO:58. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:62, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:63, and a light chain

20 constant region having the amino acid sequence of SEQ ID NO:58. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:64, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In one embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid

25 sequence of SEQ ID NO:65, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:66, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In yet another embodiment, the antibody or antigen-binding fragment thereof further comprises a

30 heavy chain constant region having the amino acid sequence of SEQ ID NO:67, and a light chain constant region having the amino acid sequence of SEQ ID NO:58. In still another embodiment, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region having the amino acid sequence of SEQ ID NO:68, and a light chain constant region

having the amino acid sequence of SEQ ID NO:58. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In certain embodiments, the antibody or antigen-binding fragment thereof comprises a
5 light chain comprising the amino acid sequence of SEQ ID NO:71 and a heavy chain comprising the amino acid sequence of SEQ ID NO:72. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In some embodiments, the antibody or antigen-binding fragment thereof comprises a
10 light chain comprising the amino acid sequence of SEQ ID NO:73 and a heavy chain comprising the amino acid sequence of SEQ ID NO:74. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In other embodiments, the antibody or antigen-binding fragment thereof comprises a light
15 chain comprising the amino acid sequence of SEQ ID NO:75 and a heavy chain comprising the amino acid sequence of SEQ ID NO:76. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In yet other embodiments, the antibody or antigen-binding fragment thereof consists of
20 two light chains comprising the amino acid sequence of SEQ ID NO:71 and two heavy chains comprising the amino acid sequence of SEQ ID NO:72. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In still other embodiments, the antibody or antigen-binding fragment thereof consists of
25 two light chains comprising the amino acid sequence of SEQ ID NO:73 and two heavy chains comprising the amino acid sequence of SEQ ID NO:74. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In yet still other embodiments, the antibody or antigen-binding fragment thereof consists
30 of two light chains comprising the amino acid sequence of SEQ ID NO:75 and two heavy chains comprising the amino acid sequence of SEQ ID NO:76. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In certain embodiments, the antibody or antigen-binding fragment thereof consists of two light chains consisting of the amino acid sequence of SEQ ID NO:71 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:72. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In some embodiments, the antibody or antigen-binding fragment thereof consists of two light chains consisting of the amino acid sequence of SEQ ID NO:73 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:74. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In other embodiments, the antibody or antigen-binding fragment thereof consists of two light chains consisting of the amino acid sequence of SEQ ID NO:75 and two heavy chains consisting of the amino acid sequence of SEQ ID NO:76. In certain embodiments, the lysine residue at the C-terminus of the heavy chain constant region is present. In other embodiments, the lysine residue at the C-terminus of the heavy chain constant region is absent.

In various embodiments of the antibody or antigen binding fragment thereof described herein, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 1×10^{-8} M or less, 9×10^{-9} M or less, 8×10^{-9} M or less, 7×10^{-9} M or less, 6×10^{-9} M or less, 5×10^{-9} M or less, 4×10^{-9} M or less, 3×10^{-9} M or less, or 2×10^{-9} M or less for tau-pS413. In certain embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 1×10^{-8} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 9×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 8×10^{-9} M or less for tau-pS413. In certain embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 7×10^{-9} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 6×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 5×10^{-9} M or less for tau-pS413. In yet other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 4×10^{-9} M or less for tau-pS413. In still other embodiments, the antibody or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 3×10^{-9} M or less for tau-pS413. In yet still other embodiments, the antibody

or antigen binding fragment thereof has an equilibrium dissociation constant (KD) of 2×10^{-9} M or less for tau-pS413. In some embodiments, the KD is measured by Surface Plasmon Resonance (SPR) assay. In certain embodiments, the KD is measured by Surface Plasmon Resonance (SPR) assay with the antibody or antigen binding fragment thereof being

5 immobilized. In other embodiments, the KD is measured by Surface Plasmon Resonance (SPR) assay with the antigen being immobilized. In one embodiment, the KD is measured by Biacore. In another embodiment, the KD is measured by KinExA. In one specific embodiment, the KD is measured by Biacore with the antibody or antigen binding fragment thereof being immobilized.

In certain embodiments, the antibody or antigen binding fragment thereof that binds to

10 tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a KD of 1×10^{-8} M or

15 less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID

20 NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a KD of 9×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1

25 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a KD of 8×10^{-9} M or less for tau-pS413. In certain embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of

30 SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a KD of 7×10^{-9} M or less for tau-pS413. In some embodiments, the

antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a K_D of 6×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a K_D of 5×10^{-9} M or less for tau-pS413. In yet other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a K_D of 4×10^{-9} M or less for tau-pS413. In still other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a K_D of 3×10^{-9} M or less for tau-pS413. In yet still other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35; and has a K_D of 2×10^{-9} M or less for tau-pS413. In a specific embodiment, the K_D is measured by Biacore with the antibody or antigen binding fragment thereof being immobilized.

In some embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 1×10^{-8} M or less for tau-pS413. In certain embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 9×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 8×10^{-9} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 7×10^{-9} M or less for tau-pS413. In certain embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 6×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 5×10^{-9} M or less for tau-pS413. In yet other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 4×10^{-9} M or less for tau-pS413. In still other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a KD of 3×10^{-9} M or less for tau-pS413. In yet still other embodiments, the antibody or antigen binding fragment thereof

that binds to tau-pS413 comprises a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36; and has a K_D of 2×10^{-9} M or less for tau-pS413. In a specific embodiment, the K_D is measured by Biacore with the antibody or antigen binding fragment thereof being immobilized.

- In certain embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 1×10^{-8} M or less for tau-pS413.
- In some embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 9×10^{-9} M or less for tau-pS413. In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 8×10^{-9} M or less for tau-pS413.
- In certain embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 7×10^{-9} M or less for tau-pS413. In some embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 6×10^{-9} M or less for tau-pS413.
- In other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 5×10^{-9} M or less for tau-pS413.
- In yet other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 4×10^{-9} M or less for tau-pS413.

In still other embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 3×10^{-9} M or less for tau-pS413.

- 5 In yet still embodiments, the antibody or antigen binding fragment thereof that binds to tau-pS413 comprises a VH comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:56 and a VL comprising at least 90% amino acid sequence identity to the amino acid sequence of SEQ ID NO:36; and has a K_D of 2×10^{-9} M or less for tau-pS413. In a specific embodiment, the K_D is measured by Biacore with the antibody or antigen binding
10 fragment thereof being immobilized.

- The present disclosure further includes functional fragments of the anti-tau-pS413 antibodies disclosed herein. Non-limiting examples of functional fragments (e.g., antigen-binding fragments such as tau-pS413-binding fragments) include single-chain Fvs (scFv) (e.g., including monospecific, bispecific, etc.), Fab fragments, F(ab') fragments, F(ab)₂ fragments,
15 F(ab')₂ fragments, disulfide-linked Fvs (dsFv), Fd fragments, Fv fragments, diabody, triabody, tetrabody, and minibody. In particular, antibodies provided herein include immunoglobulin molecules and immunologically active portions of immunoglobulin molecules, for example, antigen-binding domains or molecules that contain an antigen-binding site that binds to a tau-pS413 antigen (e.g., one or more CDRs of an anti-tau-pS413 antibody). Such antibody
20 fragments can be found in, for example, Harlow and Lane, *Antibodies: A Laboratory Manual* (1989); Mol. Biology and Biotechnology: A Comprehensive Desk Reference (Myers ed., 1995); Huston et al., 1993, *Cell Biophysics* 22:189-224; Pluckthun and Skerra, 1989, *Meth. Enzymol.* 178:497-515; Day, *Advanced Immunochemistry* (2d ed. 1990); Hudson et al., 2003, *Nature Med.* 9:129-34.

- 25 Immunoglobulins may be assigned to different classes depending on the amino acid sequences of the constant domain of their heavy chains. There are at least five major classes of immunoglobulins: IgA, IgD, IgE, IgG and IgM, and several of these may be further divided into subclasses (isotypes), e.g. IgG-1, IgG-2, IgG-3 and IgG-4; IgA-1 and IgA-2. The invention comprises antibodies and antigen binding fragments of any of these classes or subclasses of
30 antibodies.

In one embodiment, the antibody or antigen binding fragment comprises a heavy chain constant region, e.g. a human constant region, such as $\gamma 1$, $\gamma 2$, $\gamma 3$, or $\gamma 4$ human heavy chain constant region or a variant thereof. In another embodiment, the antibody or antigen binding

fragment comprises a light chain constant region, e.g. a human light chain constant region, such as lambda or kappa human light chain region or variant thereof.

Antibody Engineering of the Fc region

The antibodies disclosed herein can also be engineered to include modifications within the Fc region, typically to alter one or more functional properties of the antibody, such as serum half-life, complement fixation, Fc receptor binding, and/or effector function (e.g., antigen-dependent cellular cytotoxicity). Furthermore, the antibodies disclosed herein can be chemically modified (e.g., one or more chemical moieties can be attached to the antibody) or be modified to alter its glycosylation, again to alter one or more functional properties of the antibody. Each of these embodiments is described in further detail below. The numbering of residues in the Fc region is that of the EU index of Kabat.

The antibodies disclosed herein also include antibodies with modified (or blocked) Fc regions to provide altered effector functions. See, e.g., U.S. Pat. No. 5,624,821; WO2003/086310; WO2005/120571; WO2006/0057702. Such modification can be used to enhance or suppress various reactions of the immune system, with possible beneficial effects in diagnosis and therapy. Alterations of the Fc region include amino acid changes (substitutions, deletions and insertions), glycosylation or deglycosylation, and adding multiple Fc. Changes to the Fc can also alter the half-life of antibodies in therapeutic antibodies, enabling less frequent dosing and thus increased convenience and decreased use of material. See Presta (2005). *J. Allergy Clin. Immunol.* 116:731 at 734-35.

In one embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with two amino acid substitutions, L234A and L235A (sometimes referred to as "LALA" mutations) that reduce/ablate effector function. In another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with three amino acid substitutions, L234A, L235A and D265S that reduce/ablate effector function. In yet another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with three amino acid substitutions, M252Y, S254T, and T256E that increase half-life of the antibody in serum. In still another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with five amino acid substitutions, L234A, L235A, M252Y, S254T, and T256E that reduce/ablate effector function and increase half-life of the antibody in serum. In yet still another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with six amino acid substitutions, L234A, L235A, D265S, M252Y, S254T, and T256E that reduce/ablate effector function and increase half-life of the antibody in

serum. In another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 is modified with the amino acid substitution N297A, which eliminates a glycosylation site and reduces/ablates effector function. In still another embodiment, the constant domain (CH1-hinge-CH2-CH3) of human wild type IgG1 with the amino acid substitution N297Q, which
5 eliminates a glycosylation site and reduces/ablates effector function.

In one embodiment, the antibody is an IgG4 isotype antibody comprising a Serine to Proline mutation at an amino acid position corresponding to position 228 (S228P; EU index) in the hinge region of the heavy chain constant region. This mutation has been reported to abolish the heterogeneity of inter-heavy chain disulfide bridges in the hinge region (Angal *et al. supra*;
10 position 241 is based on the Kabat numbering system).

In one embodiment, the hinge region of CH1 is modified such that the number of cysteine residues in the hinge region is increased or decreased. This approach is described further in U.S. Patent No. 5,677,425. The number of cysteine residues in the hinge region of CH1 is altered, for example, to facilitate assembly of the light and heavy chains or to increase or
15 decrease the stability of the antibody.

In another embodiment, the antibody is modified to increase its biological half-life. Various approaches are possible. For example, one or more of the following amino acid mutations can be introduced: T252L, T254S, T256F, as described in U.S. Patent No. 6,277,375. Alternatively, to increase the biological half-life, the antibody can be altered within the CH1 or
20 CL region to contain a salvage receptor binding epitope taken from two loops of a CH2 domain of an Fc region of an IgG, as described in U.S. Patent Nos. 5,869,046 and 6,121,022.

In yet other embodiments, the Fc region is altered by replacing at least one amino acid residue with a different amino acid residue to alter the effector function(s) of the antibody. For example, one or more amino acids selected from amino acid residues at positions 234, 235, 236,
25 237, 297, 318, 320 and 322 can be replaced with a different amino acid residue such that the antibody has an altered affinity for an effector ligand but retains the antigen-binding ability of the parent antibody. The effector ligand to which affinity is altered can be, for example, an Fc receptor or the C1 component of complement. This approach is described in further detail in U.S. Patent Nos. 5,624,821 and 5,648,260.

30 In another example, one or more amino acids selected from amino acid residues at positions 329, 331 and 322 can be replaced with a different amino acid residue such that the antibody has altered C1q binding and/or reduced or abolished complement dependent cytotoxicity (CDC). This approach is described in further detail in U.S. Patent No. 6,194,551.

In another example, one or more amino acid residues within amino acid positions 231 and 239 are altered to thereby alter the ability of the antibody to fix complement. This approach is described further in PCT Publication WO 94/29351.

In yet another example, the Fc region is modified to increase or decrease the ability of the antibody to mediate antibody dependent cellular cytotoxicity (ADCC) and/or to increase or decrease the affinity of the antibody for an Fcγ receptor by modifying one or more amino acids at the following positions: 238, 239, 243, 248, 249, 252, 254, 255, 256, 258, 264, 265, 267, 268, 269, 270, 272, 276, 278, 280, 283, 285, 286, 289, 290, 292, 293, 294, 295, 296, 298, 301, 303, 305, 307, 309, 312, 315, 320, 322, 324, 326, 327, 329, 330, 331, 333, 334, 335, 337, 338, 340, 360, 373, 376, 378, 382, 388, 389, 398, 414, 416, 419, 430, 434, 435, 437, 438 or 439. This approach is described further in PCT Publication WO 00/42072. Moreover, the binding sites on human IgG1 for FcγR1, FcγR2, FcγR3 and FcRn have been mapped and variants with improved binding have been described (*see* Shields *et al.* (2001) *J. Biol. Chem.* 276:6591-6604). Specific mutations at positions 256, 290, 298, 333, 334 and 339 were shown to improve binding to FcγR3. Additionally, the following combination mutants were shown to improve FcγR3 binding: T256A/S298A, S298A/E333A, S298A/K224A and S298A/E333A/K334A.

In one embodiment, the Fc region is modified to decrease the ability of the antibody to mediate effector function and/or to increase anti-inflammatory properties by modifying amino acid residues at positions 243 and 264. In one embodiment, the Fc region of the antibody is modified by changing the amino acid residues at positions 243 and 264 to alanine. In one embodiment, the Fc region is modified to decrease the ability of the antibody to mediate effector function and/or to increase anti-inflammatory properties by modifying amino acid residues at positions 243, 264, 267 and 328.

In still another embodiment, the antibody comprises a particular glycosylation pattern. For example, an aglycosylated antibody can be made (*i.e.*, the antibody lacks glycosylation). The glycosylation pattern of an antibody may be altered to, for example, increase the affinity or avidity of the antibody for an antigen. Such modifications can be accomplished by, for example, altering one or more of the glycosylation sites within the antibody sequence. For example, one or more amino acid substitutions can be made that result removal of one or more of the variable region framework glycosylation sites to thereby eliminate glycosylation at that site. Such aglycosylation may increase the affinity or avidity of the antibody for antigen. *See, e.g.*, U.S. Patent Nos. 5,714,350 and 6,350,861.

An antibody may also be made in which the glycosylation pattern includes hypofucosylated or afucosylated glycans, such as a hypofucosylated antibodies or afucosylated antibodies have reduced amounts of fucosyl residues on the glycan. The antibody may also include glycans having an increased amount of bisecting GlcNAc structures. Such altered glycosylation patterns have been demonstrated to increase the ADCC ability of antibodies. Such modifications can be accomplished by, for example, expressing the antibody in a host cell in which the glycosylation pathway was been genetically engineered to produce glycoproteins with particular glycosylation patterns. These cells have been described in the art and can be used as host cells in which to express recombinant antibodies of the invention to thereby produce an antibody with altered glycosylation. For example, the cell lines Ms704, Ms705, and Ms709 lack the fucosyltransferase gene, FUT8 (α (1,6)-fucosyltransferase), such that antibodies expressed in the Ms704, Ms705, and Ms709 cell lines lack fucose on their carbohydrates. The Ms704, Ms705, and Ms709 FUT8^{-/-} cell lines were created by the targeted disruption of the FUT8 gene in CHO/DG44 cells using two replacement vectors (*see* U.S. Patent Publication No. 20040110704 and Yamane-Ohnuki *et al.* (2004) *Biotechnol Bioeng* 87:614-22). As another example, EP 1176195 describes a cell line with a functionally disrupted FUT8 gene, which encodes a fucosyl transferase, such that antibodies expressed in such a cell line exhibit hypofucosylation by reducing or eliminating the α -1,6 bond-related enzyme. EP 1,176,195 also describes cell lines which have a low enzyme activity for adding fucose to the N-acetylglucosamine that binds to the Fc region of the antibody or does not have the enzyme activity, for example the rat myeloma cell line YB2/0 (ATCC CRL 1662). PCT Publication WO 03/035835 describes a variant CHO cell line, Lec13 cells, with reduced ability to attach fucose to Asn(297)-linked carbohydrates, also resulting in hypofucosylation of antibodies expressed in that host cell (*see* also Shields *et al.* (2002) *J. Biol. Chem.* 277:26733-26740). Antibodies with a modified glycosylation profile can also be produced in chicken eggs, as described in PCT Publication WO 06/089231. Alternatively, antibodies with a modified glycosylation profile can be produced in plant cells, such as *Lemna* (US Patent 7,632,983). Methods for production of antibodies in a plant system are disclosed in the U.S. Patents 6,998,267 and 7,388,081. PCT Publication WO 99/54342 describes cell lines engineered to express glycoprotein-modifying glycosyl transferases (*e.g.*, β (1,4)-N-acetylglucosaminyltransferase III (GnTIII)) such that antibodies expressed in the engineered cell lines exhibit increased bisecting GlcNAc structures which results in increased ADCC activity of the antibodies (*see* also Umana *et al.* (1999) *Nat. Biotech.* 17:176-180).

Alternatively, the fucose residues of the antibody can be cleaved off using a fucosidase enzyme; *e.g.*, the fucosidase α -L-fucosidase removes fucosyl residues from antibodies (Tarentino *et al.* (1975) *Biochem.* 14:5516-23).

Antibodies disclosed herein further include those produced in lower eukaryote host cells, in particular fungal host cells such as yeast and filamentous fungi have been genetically engineered to produce glycoproteins that have mammalian- or human-like glycosylation patterns (see, for example, Choi *et al.*, (2003) *Proc. Natl. Acad. Sci.* 100: 5022-5027; Hamilton *et al.*, (2003) *Science* 301: 1244-1246; Hamilton *et al.*, (2006) *Science* 313: 1441-1443). A particular advantage of these genetically modified host cells over currently used mammalian cell lines is the ability to control the glycosylation profile of glycoproteins that are produced in the cells such that compositions of glycoproteins can be produced wherein a particular N-glycan structure predominates (see, *e.g.*, U.S. Patent No. 7,029,872 and U.S. Patent No. 7,449,308). These genetically modified host cells have been used to produce antibodies that have predominantly particular N-glycan structures (see, for example, Li *et al.*, (2006) *Nat. Biotechnol.* 24: 210-215).

15 *Antibody Conjugates*

The anti-tau-pS413 antibodies or antigen binding fragments thereof disclosed herein can also be conjugated to one or more agents (*e.g.*, a peptide or chemical moiety). The chemical moiety may be, *inter alia*, a polymer, a radionuclide, or a therapeutic or prophylactic agent. In particular embodiments, the chemical moiety is a polymer which increases the half-life of the antibody molecule in the body of a subject. Suitable polymers include, but are not limited to, hydrophilic polymers which include but are not limited to polyethylene glycol (PEG) (*e.g.*, PEG with a molecular weight of 2 kDa, 5 kDa, 10 kDa, 12 kDa, 20 kDa, 30 kDa or 40 kDa), dextran and monomethoxypolyethylene glycol (mPEG). Lee, *et al.*, (1999) (*Bioconj. Chem.* 10:973-981) discloses PEG-conjugated single-chain antibodies. Wen, *et al.*, (2001) (*Bioconj. Chem.* 12:545-553) disclose conjugating antibodies with PEG that is attached to a radiometal chelator (diethylenetriaminopentaacetic acid (DTPA)).

The antibodies and antibody fragments disclosed herein may be pegylated, for example to increase its biological (*e.g.*, serum) half-life. To pegylate an antibody, the antibody, or fragment thereof, typically is reacted with a reactive form of polyethylene glycol (PEG), such as a reactive ester or aldehyde derivative of PEG, under conditions in which one or more PEG groups become attached to the antibody or antibody fragment. In particular embodiments, the pegylation is carried out via an acylation reaction or an alkylation reaction with a reactive PEG molecule (or an analogous reactive water-soluble polymer). As used herein, the term "polyethylene glycol" is

intended to encompass any of the forms of PEG that have been used to derivatize other proteins, such as mono (C1-C10) alkoxy- or aryloxy-polyethylene glycol or polyethylene glycol-maleimide. In certain embodiments, the antibody to be pegylated is an aglycosylated antibody. Methods for pegylating proteins are known in the art and can be applied to the antibodies of the invention. *See, e.g.*, EP 0 154 316 and EP 0 401 384.

The antibodies and antibody fragments disclosed herein may also be conjugated to detectable substances including, but not limited to, various enzymes, such as, but not limited to, horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; prosthetic groups, such as, but not limited to, streptavidin/biotin or avidin/biotin; fluorescent materials, such as, but not limited to, umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride, or phycoerythrin; luminescent materials, such as, but not limited to, luminol; bioluminescent materials, such as, but not limited to, luciferase, luciferin, or aequorin; chemiluminescent material, such as, but not limited to, an acridinium based compound or a HALOTAG; radioactive materials, such as but not limited to iodine (^{131}I , ^{125}I , ^{123}I , and ^{121}I), carbon (^{14}C), sulfur (^{35}S), tritium (^3H), indium (^{115}In , ^{113}In , ^{112}In , and ^{111}In), technetium (^{99}Tc), thallium (^{201}Tl), gallium (^{68}Ga and ^{67}Ga), palladium (^{103}Pd), molybdenum (^{99}Mo), xenon (^{133}Xe), fluorine (^{18}F), ^{153}Sm , ^{177}Lu , ^{159}Gd , ^{149}Pm , ^{140}La , ^{175}Yb , ^{166}Ho , ^{90}Y , ^{47}Sc , ^{186}Re , ^{188}Re , ^{142}Pr , ^{105}Rh , ^{97}Ru , ^{68}Ge , ^{57}Co , ^{65}Zn , ^{85}Sr , ^{32}P , ^{153}Gd , ^{169}Yb , ^{51}Cr , ^{54}Mn , ^{75}Se , ^{113}Sn , or ^{117}Sn ; positron emitting metals using various positron emission tomographies; and non-radioactive paramagnetic metal ions.

In other embodiments, the antibodies or antigen binding fragments thereof can be recombinantly fused or chemically conjugated (covalent or non-covalent conjugations) to a heterologous protein or polypeptide (or fragment thereof, for example, to a polypeptide of about 10, about 20, about 30, about 40, about 50, about 60, about 70, about 80, about 90, or about 100 amino acids) to generate fusion proteins. In particular, provided herein are fusion proteins comprising an antigen-binding fragment of an antibody provided herein (e.g., a Fab fragment, Fc fragment, Fv fragment, F(ab)₂ fragment, a VH domain, a VH CDR, a VL domain, or a VL CDR) and a heterologous protein, polypeptide, or peptide. In one embodiment, the heterologous protein, polypeptide, or peptide that the antibody is fused to is useful for targeting the antibody to a particular cell type, such as a neuron cell. For example, an antibody that binds to a cell surface receptor expressed by a particular neuron cell type may be fused or conjugated to a modified antibody provided herein.

Any method known in the art for conjugating the antibody molecules to the various moieties may be employed, including those methods described by Hunter, *et al.*, (1962) *Nature* 144:945; David, *et al.*, (1974) *Biochemistry* 13:1014; Pain, *et al.*, (1981) *J. Immunol. Meth.* 40:219; and Nygren, J., (1982) *Histochem. and Cytochem.* 30:407.

5 **Methods of Using High Affinity Anti-tau-pS413 Antibodies or Antigen Binding Fragments Thereof**

The present disclosure also includes methods of using the high affinity anti-tau-pS413 antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein. These
10 antibodies can be used in treating, diagnosing, or monitoring progress of tauopathy, or decreasing the amount of tau-pS413 in the brain of a subject having tauopathy.

In one aspect, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen
15 binding fragments thereof described herein.

In yet still another aspect, provided is a method of decreasing the amount of tau-pS413 in the brain of a subject having tauopathy, comprising administering to the subject in need thereof an effective amount of the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof of
20 described herein.

In yet additional embodiments, provided is the use of an antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein to treat tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody (e.g., various isotypes
25 of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein to decrease the amount of tau-pS413 in the brain of a subject having tauopathy.

In yet additional embodiments, provided is the use of an antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or
30 antigen binding fragment thereof as disclosed herein for the treatment of tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or

antigen binding fragment thereof as disclosed herein for the preparation of a medicament to treat tauopathy in a subject.

In yet a further embodiment, provided is an antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding
5 fragment thereof as disclosed herein for use in a method for treating tauopathy in a subject.

In yet another embodiment, provided is an antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein for use in a method for decreasing the amount of tau-pS413 in the brain of a subject having tauopathy.

10 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID
15 NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
20 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino
25 acid sequence of SEQ ID NO:35.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid
30 sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid
5 sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising
10 administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:41; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:42; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:43; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2
15 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1
20 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

25 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID
30 NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid
5 sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising
10 administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2
15 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1
20 comprising the amino acid sequence of SEQ ID NO:45; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:46; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:47; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

25 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID
30 NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid
5 sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising
10 administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2
15 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1
20 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

25 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:49; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:50; and a VH-CDR3 comprising the amino acid sequence of SEQ ID
30 NO:51; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:25; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:26; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:27.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:53; a VH-CDR2 comprising the amino acid
5 sequence of SEQ ID NO:54; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:55; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:17; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:18; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:19.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising
10 administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:29; a VL-CDR2
15 comprising the amino acid sequence of SEQ ID NO:30; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:31.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1
20 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:33; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:34; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:35.

25 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:21; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:22; and a VH-CDR3 comprising the amino acid sequence of SEQ ID
30 NO:23; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:37; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:38; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:39.

In another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:86; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:87; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:88; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:83; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:84; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:85.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:92; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:93; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:94; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:89; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:90; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:91.

In still another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:98; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:99; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:100; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:95; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:96; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:97.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1 comprising the amino acid sequence of SEQ ID NO:104; a VH-CDR2 comprising the amino acid sequence of SEQ ID NO:105; and a VH-CDR3 comprising the amino acid sequence of SEQ ID NO:106; and a VL-CDR1 comprising the amino acid sequence of SEQ ID NO:101; a VL-CDR2 comprising the amino acid sequence of SEQ ID NO:102; and a VL-CDR3 comprising the amino acid sequence of SEQ ID NO:103.

In another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:44; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a

VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

5 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

10 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of
15 SEQ ID NO:40.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48;
20 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a
25 VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:48; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
30 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52;
5 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a
10 VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
15 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:28.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
20 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:52; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
25 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of
30 SEQ ID NO:32.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a

VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

5 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

10 In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of
15 SEQ ID NO:28.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:56;
20 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:20.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a
25 VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:32.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment
30 thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24; and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:36.

In one embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH-CDR1, a VH-CDR2, and a VH-CDR3 of a VH comprising the amino acid sequence of SEQ ID NO:24;
5 and a VL-CDR1, a VL-CDR2, and a VL-CDR3 of a VL comprising the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH
10 having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH
15 having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH
20 having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH
25 having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:28.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH
30 having the amino acid sequence of SEQ ID NO:44, and a VL having the amino acid sequence of SEQ ID NO:20.

In yet another embodiment, provided is a method of treating tauopathy in a subject,

comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:32.

5 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:36.

10 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:40.

15 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:28.

20 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:48, and a VL having the amino acid sequence of SEQ ID NO:20.

25 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:32.

30 In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH

having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
5 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
10 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:28.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
15 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:52, and a VL having the amino acid sequence of SEQ ID NO:20.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
20 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:32.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
25 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:36.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding
30 fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of SEQ ID NO:40.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of
5 SEQ ID NO:28.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:56, and a VL having the amino acid sequence of
10 SEQ ID NO:20.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of
15 SEQ ID NO:32.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of
20 SEQ ID NO:36.

In yet another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a VH having the amino acid sequence of SEQ ID NO:24, and a VL having the amino acid sequence of
25 SEQ ID NO:40.

In still another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a light chain comprising the amino acid sequence of SEQ ID NO:71 and a heavy chain comprising the
30 amino acid sequence of SEQ ID NO:72.

In still another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding

fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a light chain comprising the amino acid sequence of SEQ ID NO:73 and a heavy chain comprising the amino acid sequence of SEQ ID NO:74.

In still another embodiment, provided is a method of treating tauopathy in a subject, comprising administering to the subject an effective amount of an antibody or antigen binding fragment thereof, wherein the antibody or antigen binding fragment thereof comprises: a light chain comprising the amino acid sequence of SEQ ID NO:75 and a heavy chain comprising the amino acid sequence of SEQ ID NO:76.

In some embodiments, the method further comprises administering to the subject an additional agent.

In particular embodiments, the additional agent is an agent effective to treat the same or different disorder as the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein are being used to treat. In some embodiments, the additional agent is an agent effective to mitigate one or more side effects of the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein. Exemplary additional agents include, but are not limited to: cholinesterase inhibitors (such as donepezil, galantamine, rivastigmine, and tacrine), NMDA receptor antagonists (such as memantine), amyloid beta peptide aggregation inhibitors, antioxidants, gamma-secretase modulators, nerve growth factor (NGF) mimics or NGF gene therapy, PPAR γ agonists, HMG-CoA reductase inhibitors (statins), ampa/kines, calcium channel blockers, GABA receptor antagonists, glycogen synthase kinase inhibitors, intravenous immunoglobulin, muscarinic receptor agonists, nicotinic receptor modulators, active or passive amyloid beta peptide for immunization, phosphodiesterase inhibitors, serotonin receptor antagonists, anti-amyloid beta peptide antibodies, growth hormone, neurotrophic factor, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), neurotrophin-4/5, fibroblast growth factor (FGF)-2 and other FGFs, neurotrophin (NT)-3, erythropoietin (EPO), hepatocyte growth factor (HGF), epidermal growth factor (EGF), transforming growth factor (TGF)- α 1, TGF- β , vascular endothelial growth factor (VEGF), interleukin-1 receptor antagonist (IL-1ra), ciliary neurotrophic factor (CNTF), glial-derived neurotrophic factor (GDNF), neurturin, platelet-derived growth factor (PDGF), heregulin, neuregulin, artemin, persephin, interleukins, glial cell line derived neurotrophic factor (GFR), granulocyte-colony stimulating factor (CSF), granulocyte-macrophage-CSF, netrins, cardiotrophin-1, hedgehogs, leukemia inhibitory factor (LIF), midkine, pleiotrophin, bone morphogenetic proteins (BMPs), netrins, saposins, semaphorins, stem cell factor (SCF), or a different anti-tau antibody.

Such combination therapies noted above encompass combined administration (where two or more agents are included in the same or separate formulations), and separate administration, in which case, administration of the anti-tau-pS413 antibody or antigen binding fragment thereof can occur prior to, simultaneously, and/or following, administration of the additional agent and/or adjuvant. The anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein can also be used in combination with other interventional therapies such as, but not limited to, radiation therapy, behavioral therapy, or other therapies known in the art and appropriate for the neurological disorder to be treated or prevented, for example, regenerative medicine approaches that use biotechnologies including gene therapy, gene-modified cell therapy, cell therapy and tissue engineering to restore or establish normal brain function.

Anti-tau-pS413 antibodies or fragments thereof may also be useful in diagnostic assays for tau-pS413, *e.g.*, detecting its existence in specific neuron cells, brain tissues, CSF, or interstitial fluid (ISF). Such diagnostic methods may be useful in various disease diagnoses or monitoring progress of the disease.

For example, particular embodiments include ELISA assays incorporating the use of an anti-tau-pS413 antibody or antigen binding fragment thereof disclosed herein.

An exemplary method comprises the following steps:

- (a) coat a substrate (*e.g.*, surface of a microtiter plate well, *e.g.*, a plastic plate) with a first antibody or antigen binding fragment thereof;
- (b) apply a sample to be tested for the presence of tau-pS413 to the substrate;
- (c) wash the plate, so that unbound material in the sample is removed;
- (d) apply a detectably labeled second antibody (*e.g.*, enzyme-linked antibody);
- (e) wash the substrate, so that the unbound labeled second antibody is removed;
- (f) if the labeled second antibody is enzyme linked, apply a chemical which is converted by the enzyme into a fluorescent signal; and
- (g) detect the presence of the labeled second antibody.

The anti-tau-pS413 antibodies described herein can be the first antibody or the second antibody, or both the first and the second antibodies in the above exemplary method. In one embodiment, the anti-tau-pS413 antibody described herein is the first antibody, and the second antibody is a different antibody that is specific to tau or phosphorylated tau. In another embodiment, the anti-tau-pS413 antibody described herein is the second antibody, and the first antibody is a different antibody that is specific to tau or phosphorylated tau.

In a further embodiment, the labeled anti-tau-pS413 antibody is labeled with peroxidase which reacts with ABTS (*e.g.*, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid)) or 3,3',5,5'-tetramethylbenzidine to produce a color change which is detectable. Alternatively, the labeled anti-tau-pS413 antibody is labeled with a detectable radioisotope (*e.g.*, ^3H) which can be
5 detected by scintillation counter in the presence of a scintillant.

An anti-tau-pS413 antibody described herein may be used in a Western blot or immune-protein blot procedure.

An exemplary method comprises the following steps:

- (1) contacting a membrane or other solid substrate to be tested for the presence of tau-pS413 or a fragment thereof with an anti-tau-pS413 antibody or fragment described herein;
10
- (2) washing the membrane one or more times to remove unbound anti-tau-pS413 antibody or fragment and other unbound substances; and
- (3) detecting the bound anti-tau-pS413 antibody or fragment.

Such a membrane may take the form of a nitrocellulose or vinyl-based (*e.g.*,
15 polyvinylidene fluoride (PVDF)) membrane to which proteins to be tested for the presence of tau-pS413 in a non-denaturing PAGE (polyacrylamide gel electrophoresis) gel or SDS-PAGE (sodium dodecyl sulfate polyacrylamide gel electrophoresis) gel have been transferred (*e.g.*, following electrophoretic separation in the gel). Before contact of membrane with the anti-tau-pS413 antibody or fragment, the membrane is optionally blocked, *e.g.*, with non-fat dry milk or
20 the like so as to block non-specific protein binding sites on the membrane.

Detection of the bound antibody or fragment may be by binding the antibody or fragment with a secondary antibody (an anti-immunoglobulin antibody) which is detectably labeled and, then, detecting the presence of the secondary antibody.

The anti-tau-pS413 antibodies and antigen binding fragments thereof disclosed herein
25 may also be used for immunohistochemistry. Such a method forms part of the present disclosure and comprises, *e.g.*, (1) contacting a cell or tissue to be tested for the presence of tau-pS413 with an anti-tau-pS413 antibody or antigen binding fragment thereof described herein; and (2) detecting the anti-tau-pS413 antibody or antigen binding fragment thereof on or in the cell or in the tissue. If the anti-tau-pS413 antibody or fragment itself is detectably labeled, it can be
30 detected directly. Alternatively, the anti-tau-pS413 antibody or fragment may be bound by a detectably labeled secondary antibody which is detected.

The anti-tau-pS413 antibodies and antigen binding fragments thereof disclosed herein may also be used for *in vivo* imaging. Such a method may include injection of a radiolabeled

anti-tau-pS413 antibodies or antigen-binding fragment thereof into the body of a patient to be tested for the presence of tauopathy associated with the presence of tau-pS413 followed by nuclear imaging of the body of the patient to detect the presence of the labeled anti-tau-pS413 antibody or fragment, *e.g.*, at loci comprising a high concentration of the anti-tau-pS413
 5 antibody or fragment which are bound to tau-pS413 in the brain.

Imaging techniques include SPECT imaging (single photon emission computed tomography) or PET imaging (positron emission tomography). Labels include *e.g.*, iodine-123 (^{123}I) and technetium-99m ($^{99\text{m}}\text{Tc}$), *e.g.*, in conjunction with SPECT imaging or ^{11}C , ^{13}N , ^{15}O or ^{18}F , *e.g.*, in conjunction with PET imaging or Indium-111 (See *e.g.*, Gordon *et al.*, (2005)
 10 *International Rev. Neurobiol.* 67:385-440).

Thus, in additional embodiments, provided is the use of an antibody (*e.g.*, various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein to diagnose tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody (*e.g.*, various isotypes
 15 of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein to monitor progress of tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody (*e.g.*, various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or
 20 antigen binding fragment thereof as disclosed herein for the diagnosis of tauopathy in a subject.

In yet additional embodiments, provided is the use of an antibody (*e.g.*, various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein for the monitor of progress of tauopathy in a subject.

25 In yet additional embodiments, provided is an antibody (*e.g.*, various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof as disclosed herein for use in a method for diagnosing tauopathy in a subject.

In yet additional embodiments, provided is an antibody (*e.g.*, various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen
 30 binding fragment thereof as disclosed herein for use in a method for monitoring progress of tauopathy in a subject.

In some embodiments, the method of diagnosing tauopathy in a subject comprises administering to the subject an effective amount of the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein; and imaging the brain of the subject.

- 5 In other embodiments, the method of diagnosing tauopathy in a subject comprises obtaining a sample of CSF or ISF from a subject; running an immunodiagnostic assay (e.g., ELISA) with the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein; and determining whether the subject has tauopathy.
- 10 In certain embodiments, the method of monitoring progress of tauopathy in a subject comprises administering to the subject an effective amount of the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein; and imaging the brain of the subject.
- 15 In other embodiments, the method of monitoring progress of tauopathy in a subject comprises obtaining a sample of CSF or ISF from a subject; running an immunodiagnostic assay (e.g., ELISA) with the antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein; and determining progress of tauopathy in the subject.
- 20 In some embodiments of the various methods and uses described herein, the tauopathy is a neurodegenerative disease, including but not limited to Alzheimer's disease (AD), corticobasal degeneration (CBD) or corticobasal syndrome (CBS), progressive supranuclear palsy, Pick's disease, argyrophilic grain dementia (argyrophilic grain disease), multiple system tauopathy with presenile dementia (MSTD), frontotemporal dementia and parkinsonism linked to chromosome
25 17 (FTDP-17), dementia with neurofibrillary tangles, diffuse neurofibrillary tangle with calcification (DNCT), white matter tauopathy with globular glial inclusions (WMT-GGI), or frontotemporal lobar degeneration with tau pathology (FTLD-tau). In one embodiment, the tauopathy is AD. In another embodiment, the tauopathy is CBD. In yet another embodiment, the tauopathy is progressive supranuclear palsy. In still another embodiment, the tauopathy is
30 Pick's disease. In one embodiment, the tauopathy is argyrophilic grain dementia. In another embodiment, the tauopathy is MSTD. In yet another embodiment, the tauopathy is FTDP-17. In still another embodiment, the tauopathy is dementia with neurofibrillary tangles. In one

embodiment, the tauopathy is DNTC. In another embodiment, the tauopathy is WMT-GGI. In yet another embodiment, the tauopathy is FTLD-tau.

In other embodiments of the various methods and uses described herein, the tauopathy is a non-neurodegenerative disease, including but not limited to infectious diseases, such as

5 Economo's encephalitis sequela and subacute sclerosing panencephalitis, and trauma-induced conditions, such as boxer's encephalopathy. In one embodiment, the tauopathy is Economo's encephalitis sequela. In another embodiment, the tauopathy is subacute sclerosing panencephalitis. In yet another embodiment, the tauopathy is boxer's encephalopathy.

Nucleic Acids, Expression Vectors, Cells, and Methods of Making Anti-tau-pS413

10 Antibodies or Antigen Binding Fragments Thereof

Also provided herein are isolated nucleic acids and vectors comprising polynucleotide sequences encoding such high affinity antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) disclosed herein or antigen

15 binding fragments thereof, cells (e.g., host cells) comprising such isolated nucleic acids or vectors, and methods of making such high affinity antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof.

In one aspect, provided is an isolated nucleic acid encoding various polypeptides disclosed herein.

20 In certain embodiments, the isolated nucleic acid encodes the VH (e.g., SEQ ID NO:44, 48, 52, 56, or 24) of various antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein. In some embodiments, the isolated nucleic acid encodes the VL (e.g., SEQ ID NO:32, 36, 40, 28, or 20) of various antibodies (e.g., various isotypes of V1-AFM, V2-AFM,

25 V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein. In other embodiments, the isolated nucleic acid encodes the VH (e.g., SEQ ID NO:44, 48, 52, 56, or 24) and the VL (e.g., SEQ ID NO:32, 36, 40, 28, or 20) of various antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein.

30 In certain embodiments, the isolated nucleic acid encodes the heavy chain (e.g., SEQ ID NO:72, 74 or 76) of various antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein. In some embodiments, the isolated nucleic acid encodes the light chain (e.g.,

SEQ ID NO:71, 73, or 75) of various antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein. In other embodiments, the isolated nucleic acid encodes the heavy chain (e.g., SEQ ID NO:72, 74 or 76) and the light chain (e.g., SEQ ID NO:71, 73, or 75) of
5 various antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof disclosed herein.

In one embodiment, the isolated nucleic acid encodes a VH domain comprising the VH-CDR1, VH-CDR2 and VH-CDR3 as disclosed in **TABLE 5**.

In another embodiment, the isolated nucleic acid encodes a VL domain comprising the
10 VL-CDR1, VL-CDR2 and VL-CDR3 as disclosed in **TABLE 6**.

In yet another embodiment, the isolated nucleic acid encodes a VH domain comprising the VH-CDR1, VH-CDR2 and VH-CDR3 as disclosed in **TABLE 5** and a VL domain comprising the VL-CDR1, VL-CDR2 and VL-CDR3 as disclosed in **TABLE 6**.

In a specific embodiment, the isolated nucleic acid comprises a nucleotide sequence as
15 set forth in SEQ ID NO:107. In another specific embodiment, the isolated nucleic acid comprises a nucleotide sequence as set forth in SEQ ID NO:108.

In still another embodiment, the nucleic acids further encode a signal sequence.

In another aspect, provided is an expression vector comprising one or more of the various isolated nucleic acids disclosed herein, wherein the nucleic acid(s) is operably linked to control
20 sequences that are recognized by a host cell when the host cell is transfected with the expression vector.

In yet another aspect, provided is host cell comprising one or more of the various isolated nucleic acids or the various expression vectors disclosed herein. In some embodiments, the host cell comprises one or more of the various isolated nucleic acids disclosed herein. In other
25 embodiments, the host cell comprises one or more of the various expression vectors disclosed herein.

In still another aspect, provided are methods of making the antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof disclosed herein, comprising: culturing a host cell
30 comprising an expression vector encoding the antibody or antigen binding fragment thereof in culture medium under conditions wherein the antibody or antigen binding fragment thereof is expressed.

Also provided are methods of making the antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof disclosed herein, comprising: expressing an expression vector that comprises one or more isolated nucleic acid(s) disclosed herein under conditions wherein the antibody or antigen binding fragment thereof is expressed.

Further provided are methods of making the antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof disclosed herein, comprising: expressing one or more isolated nucleic acid(s) disclosed herein under conditions wherein the antibody or antigen binding fragment thereof is expressed.

In certain embodiments of various methods of making the antibody (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragment thereof disclosed herein, the method further comprises isolating the antigen or antigen binding fragment thereof from the host cell or culture medium, or in vitro expression system.

Mammalian cell lines available as hosts for expression of the antibodies or fragments disclosed herein are well known in the art and include many immortalized cell lines available from the American Type Culture Collection (ATCC). These include, *inter alia*, Chinese hamster ovary (CHO) cells, NSO, SP2 cells, HeLa cells, baby hamster kidney (BHK) cells, monkey kidney cells (COS), human hepatocellular carcinoma cells (e.g., Hep G2), A549 cells, 3T3 cells, HEK-293 cells and a number of other cell lines. Other cell lines that may be used are insect cell lines, such as Sf9 cells, amphibian cells, bacterial cells, plant cells and fungal cells. Various modifications can be introduced into the genome of these cell lines (e.g., glutamine synthetase knockout, auxotrophic mutations, etc.) to achieve desired properties of the host cells and/or desired properties of the expressed antibodies or antigen binding fragments thereof.

When recombinant expression vectors encoding the heavy chain or antigen binding fragment thereof and/or the light chain or antigen binding fragment thereof are introduced into host cells, the antibody or antigen binding fragment thereof is produced by culturing the host cells for a period of time sufficient to allow for expression of the antibody or antigen binding fragment thereof in the host cells or, more preferably, secretion of the antibody or antigen binding fragment thereof into the culture medium in which the host cells are grown.

Antibodies can be recovered from the culture medium using standard protein purification methods.

In general, glycoproteins produced in a particular cell line or transgenic animal will have a glycosylation pattern that is characteristic for glycoproteins produced in the cell line or transgenic animal. Therefore, the particular glycosylation pattern of an antibody will depend on the particular cell line or transgenic animal used to produce the antibody. However, all
5 antibodies encoded by the nucleic acid molecules provided herein, or comprising the amino acid sequences provided herein, comprise the instant invention, independent of the glycosylation pattern the antibodies may have. Similarly, in particular embodiments, antibodies with a glycosylation pattern comprising only non-fucosylated *N*-glycans may be advantageous, because these antibodies have been shown to typically exhibit more potent efficacy than their fucosylated
10 counterparts both *in vitro* and *in vivo* (See for example, Shinkawa et al., J. Biol. Chem. 278: 3466-3473 (2003); U.S. Patent Nos. 6,946,292 and 7,214,775). These antibodies with non-fucosylated *N*-glycans are not likely to be immunogenic because their carbohydrate structures are a normal component of the population that exists in human serum IgG.

Pharmaceutical Compositions and Administration

15 In another aspect, provided is a composition comprising the anti-tau-pS413 antibodies (e.g., various isotypes of V1-AFM, V2-AFM, V3-AFM, V4-AFM, V5-AFM, V6-AFM, V7-AFM, or V8-AFM) or antigen binding fragments thereof described herein and a pharmaceutically acceptable carrier.

In some embodiments, the composition further comprises an additional agent.

20 In particular embodiments, the additional agent is an agent effective to treat the same or different disorder as the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein are being used to treat. In some embodiments, the additional agent is an agent effective to relieve side effects of the anti-tau-pS413 antibodies or antigen-binding fragments thereof disclosed herein. Exemplary additional agents include, but are not limited to:
25 cholinesterase inhibitors (such as donepezil, galantamine, rivastigmine, and tacrine), NMDA receptor antagonists (such as memantine), amyloid beta peptide aggregation inhibitors, antioxidants, gamma-secretase modulators, nerve growth factor (NGF) mimics or NGF gene therapy, PPAR γ agonists, HMG-CoA reductase inhibitors (statins), amphotericins, calcium channel blockers, GABA receptor antagonists, glycogen synthase kinase inhibitors, intravenous
30 immunoglobulin, muscarinic receptor agonists, nicotinic receptor modulators, active or passive amyloid beta peptide for immunization, phosphodiesterase inhibitors, serotonin receptor antagonists, anti-amyloid beta peptide antibodies, growth hormone, neurotrophic factor, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), neurotrophin-4/5, fibroblast

- growth factor (FGF)-2 and other FGFs, neurotrophin (NT)-3, erythropoietin (EPO), hepatocyte growth factor (HGF), epidermal growth factor (EGF), transforming growth factor (TGF)- α , TGF- β , vascular endothelial growth factor (VEGF), interleukin-1 receptor antagonist (IL-1ra), ciliary neurotrophic factor (CNTF), glial-derived neurotrophic factor (GDNF), neurturin,
- 5 platelet-derived growth factor (PDGF), heregulin, neuregulin, artemin, persephin, interleukins, glial cell line derived neurotrophic factor (GFR), granulocyte-colony stimulating factor (CSF), granulocyte-macrophage-CSF, netrins, cardiotrophin-1, hedgehogs, leukemia inhibitory factor (LIF), midkine, pleiotrophin, bone morphogenetic proteins (BMPs), netrins, saposins, semaphorins, stem cell factor (SCF), or a different anti-tau antibody.
- 10 To prepare pharmaceutical or sterile compositions of the anti-tau-pS413 antibody or antigen binding fragment thereof described herein, the antibody or antigen binding fragment thereof is admixed with a pharmaceutically acceptable carrier or excipient. See, *e.g.*, *Remington's Pharmaceutical Sciences* and *U.S. Pharmacopeia: National Formulary*, Mack Publishing Company, Easton, PA (1984).
- 15 Formulations of therapeutic and diagnostic agents may be prepared by mixing with acceptable carriers, excipients, or stabilizers in the form of, *e.g.*, lyophilized powders, slurries, aqueous solutions or suspensions (see, *e.g.*, Hardman, *et al.* (2001) *Goodman and Gilman's The Pharmacological Basis of Therapeutics*, McGraw-Hill, New York, NY; Gennaro (2000) *Remington: The Science and Practice of Pharmacy*, Lippincott, Williams, and Wilkins, New
- 20 York, NY; Avis, *et al.* (eds.) (1993) *Pharmaceutical Dosage Forms: Parenteral Medications*, Marcel Dekker, NY; Lieberman, *et al.* (eds.) (1990) *Pharmaceutical Dosage Forms: Tablets*, Marcel Dekker, NY; Lieberman, *et al.* (eds.) (1990) *Pharmaceutical Dosage Forms: Disperse Systems*, Marcel Dekker, NY; Weiner and Kotkoskie (2000) *Excipient Toxicity and Safety*, Marcel Dekker, Inc., New York, NY).
- 25 Toxicity and therapeutic efficacy of the antibody compositions, administered alone or in combination with another agent, can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, *e.g.*, for determining the LD₅₀ (the dose lethal to 50% of the population) and the ED₅₀ (the dose therapeutically effective in 50% of the population). The dose ratio between toxic and therapeutic effects is the therapeutic index (LD₅₀/ED₅₀). In
- 30 particular aspects, antibodies exhibiting high therapeutic indices are desirable. The data obtained from these cell culture assays and animal studies can be used in formulating a range of dosage for use in human. The dosage of such compounds lies preferably within a range of circulating

concentrations that include the ED₅₀ with little or no toxicity. The dosage may vary within this range depending upon the dosage form employed and the route of administration.

In a further embodiment, a composition comprising an antibody or antibody fragment disclosed herein is administered to a subject in accordance with the Physicians' Desk Reference 5 2003 (Thomson Healthcare; 57th edition (November 1, 2002)).

The mode of administration can vary. Suitable routes of administration include oral, rectal, transmucosal, intestinal, parenteral, intramuscular, subcutaneous, intradermal, intramedullary, intrathecal, direct intraventricular, intravenous, intraperitoneal, intranasal, intraocular, inhalation, insufflation, topical, cutaneous, transdermal, or intra-arterial.

10 In particular embodiments, the anti-tau-pS413 antibody or antigen binding fragment thereof can be administered by an invasive route such as by injection (see above). In further embodiments of the invention, the anti-tau-pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered intravenously, subcutaneously, intrathecally, intramuscularly, or intracerebrally. In one specific embodiment, the anti-tau-
15 pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered intravenously. In another specific embodiment, the anti-tau-pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered subcutaneously. In yet another specific embodiment, the anti-tau-pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered intrathecally.
20 In still another specific embodiment, the anti-tau-pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered intramuscularly. In still another specific embodiment, the anti-tau-pS413 antibody or antigen binding fragment thereof, or pharmaceutical composition thereof, is administered intracerebrally.

25 Compositions can be administered with medical devices known in the art. For example, a pharmaceutical composition of the invention can be administered by injection with a hypodermic needle, including, e.g., a prefilled syringe or autoinjector.

The pharmaceutical compositions disclosed herein may also be administered by infusion.

30 The administration regimen depends on several factors, including the serum or tissue turnover rate of the therapeutic antibody, the ratio of the therapeutic antibody that crosses the blood-brain barrier, the level of symptoms, the immunogenicity of the therapeutic antibody, and the accessibility of the target cells in the biological matrix. Preferably, the administration regimen delivers sufficient therapeutic antibody to effect improvement in the target disease state, while simultaneously minimizing undesired side effects. Accordingly, the amount of biologic

delivered depends in part on the particular therapeutic antibody and the severity of the condition being treated. Guidance in selecting appropriate doses of therapeutic antibodies is available (see, e.g., Wawrzynczak (1996) *Antibody Therapy*, Bios Scientific Pub. Ltd, Oxfordshire, UK; Kresina (ed.) (1991) *Monoclonal Antibodies, Cytokines and Arthritis*, Marcel Dekker, New York, NY; Bach (ed.) (1993) *Monoclonal Antibodies and Peptide Therapy in Autoimmune Diseases*, Marcel Dekker, New York, NY; Baert, *et al.* (2003) *New Engl. J. Med.* 348:601-608; Milgrom *et al.* (1999) *New Engl. J. Med.* 341:1966-1973; Slamon *et al.* (2001) *New Engl. J. Med.* 344:783-792; Beniaminovitz *et al.* (2000) *New Engl. J. Med.* 342:613-619; Ghosh *et al.* (2003) *New Engl. J. Med.* 348:24-32; Lipsky *et al.* (2000) *New Engl. J. Med.* 343:1594-1602).

Determination of the appropriate dose is made by the clinician, e.g., using parameters or factors known or suspected in the art to affect treatment. Generally, the dose begins with an amount somewhat less than the optimum dose and it is increased by small increments thereafter until the desired or optimum effect is achieved relative to any negative side effects. In general, it is desirable that a biologic that will be used is derived from the same species as the animal targeted for treatment, thereby minimizing any immune response to the reagent. In the case of human subjects, for example, chimeric, humanized and fully human antibodies are may be desirable.

As previously described, the anti-tau-pS413 antibodies or antigen binding fragments thereof may be coadministered with one or more additional agents. The antibody may be linked to the agent (as an immunocomplex) or can be administered separately from the agent (fixed dose). In the latter case (separate administration), the antibody can be administered before, after, or concurrently with the agent or can be co-administered with other known therapies.

Kits

Also provided herein are kits comprising an antibody (e.g., an anti-tau-pS413 antibody) provided herein, or a composition (e.g., a pharmaceutical composition) thereof, packaged into suitable packaging material. A kit optionally includes a label or packaging insert including a description of the components or instructions for use in vitro, in vivo, or ex vivo, of the components therein.

The term "packaging material" refers to a physical structure housing the components of the kit. The packaging material can maintain the components sterile, and can be made of material commonly used for such purposes (e.g., paper, corrugated fiber, glass, plastic, foil, ampoules, vials, tubes, etc.).

- Kits provided herein can include labels or inserts. Labels or inserts include "printed matter," e.g., paper or cardboard, separate or affixed to a component, a kit or packing material (e.g., a box), or attached to, for example, an ampoule, tube, or vial containing a kit component. Labels or inserts can additionally include a computer readable medium, such as a disk (e.g., hard disk, card, memory disk), optical disk such as CD- or DVD-ROM/RAM, DVD, MP3, magnetic tape, or an electrical storage media such as RAM and ROM or hybrids of these such as magnetic/optical storage media, FLASH media, or memory type cards. Labels or inserts can include information identifying manufacturer information, lot numbers, manufacturer location, and date.
- Kits provided herein can additionally include other components. Each component of the kit can be enclosed within an individual container, and all of the various containers can be within a single package. Kits can also be designed for cold storage. A kit can further be designed to contain antibodies provided herein, or cells that contain nucleic acids encoding the antibodies provided herein. The cells in the kit can be maintained under appropriate storage conditions until ready to use.

GENERAL METHODS

- Standard methods in molecular biology are described in Sambrook, Fritsch and Maniatis (1982 & 1989 2nd Edition, 2001 3rd Edition) *Molecular Cloning, A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY; Sambrook and Russell (2001) *Molecular Cloning, 3rd ed.*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY; Wu (1993) *Recombinant DNA*, Vol. 217, Academic Press, San Diego, CA). Standard methods also appear in Ausbel, *et al.* (2001) *Current Protocols in Molecular Biology, Vols. 1-4*, John Wiley and Sons, Inc. New York, NY, which describes cloning in bacterial cells and DNA mutagenesis (Vol. 1), cloning in mammalian cells and yeast (Vol. 2), glycoconjugates and protein expression (Vol. 3), and bioinformatics (Vol. 4).
- Methods for protein purification including immunoprecipitation, chromatography, electrophoresis, centrifugation, and crystallization are described (Coligan, *et al.* (2000) *Current Protocols in Protein Science, Vol. 1*, John Wiley and Sons, Inc., New York). Chemical analysis, chemical modification, post-translational modification, production of fusion proteins, glycosylation of proteins are described (see, *e.g.*, Coligan, *et al.* (2000) *Current Protocols in Protein Science, Vol. 2*, John Wiley and Sons, Inc., New York; Ausubel, *et al.* (2001) *Current Protocols in Molecular Biology, Vol. 3*, John Wiley and Sons, Inc., NY, NY, pp. 16.0.5-

16.22.17; Sigma-Aldrich, Co. (2001) *Products for Life Science Research*, St. Louis, MO; pp. 45-89; Amersham Pharmacia Biotech (2001) *BioDirectory*, Piscataway, N.J., pp. 384-391).

Production, purification, and fragmentation of polyclonal and monoclonal antibodies are described (Coligan, *et al.* (2001) *Current Protocols in Immunology*, Vol. 1, John Wiley and Sons, Inc., New York; Harlow and Lane (1999) *Using Antibodies*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY; Harlow and Lane, *supra*). Standard techniques for characterizing ligand/receptor interactions are available (see, *e.g.*, Coligan, *et al.* (2001) *Current Protocols in Immunology*, Vol. 4, John Wiley, Inc., New York).

Monoclonal, polyclonal, and humanized antibodies can be prepared (see, *e.g.*, Sheperd and Dean (eds.) (2000) *Monoclonal Antibodies*, Oxford Univ. Press, New York, NY; Kontermann and Dubel (eds.) (2001) *Antibody Engineering*, Springer-Verlag, New York; Harlow and Lane (1988) *Antibodies A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, pp. 139-243; Carpenter, *et al.* (2000) *J. Immunol.* 165:6205; He, *et al.* (1998) *J. Immunol.* 160:1029; Tang *et al.* (1999) *J. Biol. Chem.* 274:27371-27378; Baca *et al.* (1997) *J. Biol. Chem.* 272:10678-10684; Chothia *et al.* (1989) *Nature* 342:877-883; Foote and Winter (1992) *J. Mol. Biol.* 224:487-499; U.S. Pat. No. 6,329,511).

An alternative to humanization is to use human antibody libraries displayed on phage or human antibody libraries in transgenic mice (Vaughan *et al.* (1996) *Nature Biotechnol.* 14:309-314; Barbas (1995) *Nature Medicine* 1:837-839; Mendez *et al.* (1997) *Nature Genetics* 15:146-156; Hoogenboom and Chames (2000) *Immunol. Today* 21:371-377; Barbas *et al.* (2001) *Phage Display: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York; Kay *et al.* (1996) *Phage Display of Peptides and Proteins: A Laboratory Manual*, Academic Press, San Diego, CA; de Bruin *et al.* (1999) *Nature Biotechnol.* 17:397-399).

Methods for flow cytometry, including fluorescence activated cell sorting (FACS), are available (see, *e.g.*, Owens, *et al.* (1994) *Flow Cytometry Principles for Clinical Laboratory Practice*, John Wiley and Sons, Hoboken, NJ; Givan (2001) *Flow Cytometry*, 2nd ed.; Wiley-Liss, Hoboken, NJ; Shapiro (2003) *Practical Flow Cytometry*, John Wiley and Sons, Hoboken, NJ). Fluorescent reagents suitable for modifying nucleic acids, including nucleic acid primers and probes, polypeptides, and antibodies, for use, *e.g.*, as diagnostic reagents, are available (Molecular Probes (2003) *Catalogue*, Molecular Probes, Inc., Eugene, OR; Sigma-Aldrich (2003) *Catalogue*, St. Louis, MO).

Standard methods of histology of the immune system are described (see, *e.g.*, Muller-Harmelink (ed.) (1986) *Human Thymus: Histopathology and Pathology*, Springer Verlag, New

York, NY; Hiatt, *et al.* (2000) *Color Atlas of Histology*, Lippincott, Williams, and Wilkins, Phila, PA; Louis, *et al.* (2002) *Basic Histology: Text and Atlas*, McGraw-Hill, New York, NY).

Software packages and databases for determining, *e.g.*, antigenic fragments, leader sequences, protein folding, functional domains, glycosylation sites, and sequence alignments, are available (see, *e.g.*, GenBank, Vector NTI® Suite (Informax, Inc, Bethesda, MD); GCG Wisconsin Package (Accelrys, Inc., San Diego, CA); DeCypher® (TimeLogic Corp., Crystal Bay, Nevada); Menne, *et al.* (2000) *Bioinformatics* 16: 741-742; Menne, *et al.* (2000) *Bioinformatics Applications Note* 16:741-742; Wren, *et al.* (2002) *Comput. Methods Programs Biomed.* 68:177-181; von Heijne (1983) *Eur. J. Biochem.* 133:17-21; von Heijne (1986) *Nucleic Acids Res.* 14:4683-4690).

Example 1. Affinity Maturation and Point Mutation

HmzTa1505-hIgG4-S228P is a humanized antibody that was generated from the mouse parental antibody Ta1505-mIgG2a, the details of which are documented in WO 2018/254390.

Affinity maturation of HmzTa1505-hIgG4-S228P was performed via yeast display screening of a structure-based designed affinity maturation library. The library design was guided by the apo Ta1505 Fab crystal structure with the introduction of 79:7:7:7 non-equimolar (doped) partially randomized mutations at the DNA level to solvent-exposed heavy chain and light chain CDR residues. Three initial libraries were created and screened; the libraries consisted of mutations in CDR-H1/H2 (9 residues total), CDR-H3 (8 residues total), and CDR-VL (12 residues total). FACS sorting of yeast cells labeled with biotinylated tau-pS413 peptide and anti-kappa light chain was used to isolate leads with increased affinity while maintaining phospho-specificity. FACS sorted outputs from the initial libraries were later combined to generate a final combined VH/VL yeast display library for synergistic improvement and screened in the same manner. Thirty hits from the combined library were reformatted to hIgG4-S228P isotype and produced recombinantly, followed by Biacore and protein analytics. One of the top hits was V1-AFM-hIgG4-S228P, which showed a 10-fold improvement in monovalent affinity and >40x improvement in binding to phosphorylated Tau in AD patient cerebrospinal fluid (CSF), compared to HmzTa1505-hIgG4-S228P (see **TABLE 8**).

VH or VL from the top hits of affinity maturation were switched and matched with VL or VH of another top hit to generate more antibody variants.

An additional mutation (K54E or K54D) in various VHs was identified via structure-based design with the goal of identifying mutations that lowered the isoelectric point (pI) while

maintaining or improving the affinity. The designs were guided by computational saturation mutagenesis and a co-crystal of Ta1505 Fab bound to a tau-pS413 peptide.

For example, addition of K54E to the VH of V1-AFM generated V6-AFM. V6-AFM-hIgG1-LALA-YTE showed lower pI (8.54) compared to V1-AFM-hIgG1-LALA-YTE (pI = 8.87). Compared to V1-AFM, V6-AFM exhibited improved monovalent affinity to tau-pS413 on all 3 isotypes tested (hIgG1-LALA, hIgG1-LALA-YTE, and hIgG4-S228P) (see **TABLE 8**). Surprisingly, V6-AFM even exhibited improved production of the antibody molecules on IgG1-LALA isotype (data not shown) and IgG1-LALA-YTE isotype (**FIG. 6**), compared with V1-AFM.

In another embodiment, K54E mutation in the VH of V2-AFM was replaced with K54D. Compared with a reference antibody (pI = 8.28) having K at position 54 of the VH of V2-AFM, both E and D mutations at position 54 reduced the pI to 7.58. In addition, K54E and K54D mutations increased the KD of the reference antibody by 1.9- and 1.4- fold, respectively.

Finally, different heavy chain isotype constant regions (e.g., IgG1, IgG1-LALA, IgG1-LALA-YTE, IgG4, IgG4-S228P) were added to the VH of various exemplary antibodies.

Exemplary antibodies generated are described in **TABLE 4**. Corresponding SEQ ID NOs for various VH and VH-CDRs (defined by the Kabat numbering system) are listed in **TABLE 5** and SEQ ID NOs for various VL and VL-CDRs (defined by the Kabat numbering system) are listed in **TABLE 6**. To illustrate how different CDR numbering systems affect the sequences of CDRs in an antibody, CDRs of V8-AFM defined by commonly used numbering systems are listed in **TABLE 7**.

TABLE 4. Exemplary antibodies

Antibody Name	Heavy Chain Isotype	VH	VL	Description (heavy chain / light chain)
Ta1505-mIgG2a	mIgG2a	Ta1505-VH	Ta1505-VL	Mouse x [MAPT_H] mAb (Ta1505) IgG2a / Kappa
V0-hIgG1	hIgG1	VH11	VL46	Humanized x [MAPT_H] mAb (Ta1505 VL46 / VH11) IgG1 / Kappa (CX)
V0-hIgG4-S228P	hIgG4 (S228P)	VH11	VL46	Humanized x [MAPT_H] mAb (Ta1505 VL46 / VH11) IgG4 S228P / Kappa (CX)
HmzTa1505-hIgG4-S228P	hIgG4 (S228P)	VH11	VL46_G34A_S28N	Humanized x [MAPT_H] mAb (Ta1505-VL46_G34A_S28N / VH11) IgG4 S228P / Kappa (CX)
V1-AFM-	hIgG4 (S228P)	VH11_A59V_D68G	VL46_G34A_S28N_Q	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G/VL46_G34A_S28N

hIgG4-S228P			27H_S32R_H98Y	Q27H_S32R_H98Y) IgG4 S228P / Kappa (CX)
V1-AFM-hIgG1-LALA	hIgG1 (LALA)	VH11_A59V_D68G	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V1-AFM-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11_A59V_D68G	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)
V2-hIgG1-LALA	hIgG1 (LALA)	VH11_D68G_K54E	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_D68G_K54E / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V2-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11_D68G_K54E	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_D68G_K54E / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)
V3-AFM-hIgG4-S228P	hIgG4 (S228P)	VH11_D68G	VL46_G34A_S28K_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11_D68G/Ta1505-VL46_G34A_S28K_S32R_H98Y) IgG4 S228P / Kappa (CX)
V4-AFM-hIgG1-LALA	hIgG1 (LALA)	VH11_D68G_K54E	VL46_G34A_S28K_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_D68G_K54E / VL46_G34A_S28K_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V4-AFM-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11_D68G_K54E	VL46_G34A_S28K_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_D68G_K54E / VL46_G34A_S28K_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)
V5-AFM-hIgG4-S228P	hIgG4 (S228P)	VH11_A59V_D68G	VL46_G34A_S28K_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G / VL46_G34A_S28K_S32R_H98Y) IgG4 S228P / Kappa (CX)
V6-AFM-hIgG4-S228P	hIgG4 (S228P)	VH11_A59V_D68G_K54E	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG4 S228P / Kappa (CX)
V6-AFM-hIgG1-LALA	hIgG1 (LALA)	VH11_A59V_D68G_K54E	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V6-AFM-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11_A59V_D68G_K54E	VL46_G34A_S28N_Q27H_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28N_Q27H_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)
V7-AFM-hIgG4-S228P	hIgG4 (S228P)	VH11	VL46_G34A_S28N_Q27R_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11/VL46_G34A_S28N_Q27R_S32R_H98Y) IgG4 S228P / Kappa (CX)

V7-AFM-hIgG1-LALA	hIgG1 (LALA)	VH11	VL46_G34A_S28N_Q27R_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11 / VL46_G34A_S28N_Q27R_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V7-AFM-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11	VL46_G34A_S28N_Q27R_S32R_H98Y	Humanized x [MAPT_H] mAb (Ta1505-VH11 / VL46_G34A_S28N_Q27R_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)
V8-AFM-hIgG4-S228P	hIgG4 (S228P)	VH11_A59V_D68G_K54E	VL46_G34A_S28K_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28K_S32R_H98Y) IgG4 S228P / Kappa (CX)
V8-AFM-hIgG1-LALA	hIgG1 (LALA)	VH11_A59V_D68G_K54E	VL46_G34A_S28K_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28K_S32R_H98Y) IgG1 L234A L235A / Kappa (CX)
V8-AFM-hIgG1-LALAYTE	hIgG1 (LALAYTE)	VH11_A59V_D68G_K54E	VL46_G34A_S28K_S32R_H98Y	Humanized Modified x [MAPT_H] mAb (Ta1505-VH11_A59V_D68G_K54E / VL46_G34A_S28K_S32R_H98Y) IgG1 L234A L235A YTE / Kappa (CX)

TABLE 5. SEQ ID NOs for VH and VH-CDRs (defined by the Kabat numbering system)

Heavy chain name	VH-CDR1	VH-CDR2	VH-CDR3	VH
VH11_D68G	SEQ ID NO:41	SEQ ID NO:42	SEQ ID NO:43	SEQ ID NO:44
VH11_A59V_D68G	SEQ ID NO:45	SEQ ID NO:46	SEQ ID NO:47	SEQ ID NO:48
VH11_D68G_K54E	SEQ ID NO:49	SEQ ID NO:50	SEQ ID NO:51	SEQ ID NO:52
VH11_A59V_D68G_K54E	SEQ ID NO:53	SEQ ID NO:54	SEQ ID NO:55	SEQ ID NO:56
VH11	SEQ ID NO:21	SEQ ID NO:22	SEQ ID NO:23	SEQ ID NO:24

TABLE 6. SEQ ID NOs for VL and VL-CDRs (defined by the Kabat numbering system)

Light chain name	VL-CDR1	VL-CDR2	VL-CDR3	VL
VL46_G34A_S28N_Q27R_S32R_H98Y	SEQ ID NO:29	SEQ ID NO:30	SEQ ID NO:31	SEQ ID NO:32
VL46_G34A_S28K_S32R_H98Y	SEQ ID NO:33	SEQ ID NO:34	SEQ ID NO:35	SEQ ID NO:36

VL46_G34A_S28N_Q27H_S32R_H98Y	SEQ ID NO:37	SEQ ID NO:38	SEQ ID NO:39	SEQ ID NO:40
VL46_G34A_S28N	SEQ ID NO:25	SEQ ID NO:26	SEQ ID NO:27	SEQ ID NO:28
VL46	SEQ ID NO:17	SEQ ID NO:18	SEQ ID NO:19	SEQ ID NO:20

TABLE 7. CDR sequences of V8-AFM defined by different numbering systems

CDR name	Kabat	AbM	Chothia	Contact	IMGT
VL-CDR1	RSSQKIVH RNANTYLE (SEQ ID NO:33)	RSSQKIVHR NANTYLE (SEQ ID NO:83)	RSSQKIVH RNANTYLE (SEQ ID NO:89)	VHRNANTY LEWY (SEQ ID NO:95)	QKIVHRNA NTY (SEQ ID NO:101)
VL-CDR2	TVSNRFS (SEQ ID NO:34)	TVSNRFS (SEQ ID NO:84)	TVSNRFS (SEQ ID NO:90)	LLIYTVSNR F (SEQ ID NO:96)	TV (SEQ ID NO:102)
VL-CDR3	FQGSYLPL T (SEQ ID NO:35)	FQGSYLPLT (SEQ ID NO:85)	FQGSYLPL T (SEQ ID NO:91)	FQGSYLPL (SEQ ID NO:97)	FQGSYLPLT (SEQ ID NO:103)
VH-CDR1	SFALN (SEQ ID NO:53)	GFTFSSFALN (SEQ ID NO:86)	GFTFSSF (SEQ ID NO:92)	SSFALN (SEQ ID NO:98)	GFTFSSFA (SEQ ID NO:104)
VH-CDR2	HIRSETNN YVTFYAA SVKG (SEQ ID NO:54)	HIRSETNNY VTF (SEQ ID NO:87)	RSETNNYV (SEQ ID NO:93)	WVGHIRSE TNMYVTF (SEQ ID NO:99)	IRSETNNYV (SEQ ID NO:105)
VH-CDR3	RGPRDSW FGY (SEQ ID NO:55)	RGPRDSWFG Y (SEQ ID NO:88)	RGPRDSWF GY (SEQ ID NO:94)	VRRGPRDS WFG (SEQ ID NO:100)	VRRGPRDS WFGY (SEQ ID NO:106)

Sequence alignment among exemplary VHs is shown in **FIG. 1A**, and sequence
5 alignment among exemplary VLs is shown in **FIG. 1B**.

Example 2. Determination of binding affinity to Tau-pS413 Peptide by Surface Plasmon Resonance (SPR)

SPR assay was used to determine the monovalent binding affinities of mAbs to a tau-pS413 peptide (SEQ ID NO:109). Antibodies were amine coupled to a CM5 sensor chip at
10 approximately 1000 RUs each. Binding assays were performed using HBS-EP running buffer containing 3 mM EDTA and 0.05% Tween-20, pH 7.4. Titrating concentrations (200 nM top for HmzTa1505-hIgG4-S228P, 80 nM top for all other mAbs, 6-point, 2.5-fold dilution series and

two zeros) of the tau-pS413 peptide were injected over the immobilized mAbs. For each injection, the tau-pS413 peptide was allowed to associate for 180 seconds, followed by dissociation for 900 seconds. Each sample injection was followed by an injection of 20 mM sodium acetate, pH 3.5, for 60 seconds to regenerate the surface for subsequent injection. All assays were run on Biacore T200 and / or 4000 instruments (GE Healthcare) and the data were fit to a 1:1 binding model using Biaevaluation software. Affinity was calculated from association and dissociation rate constants as $K_D = k_{off} / k_{on}$.

All mAbs bound the tau-pS413 peptide (**TABLE 8**). All affinity matured antibody variants (V1-AFM through V8-AFM) exhibited about 2- to about 30-fold affinity increase compared to HmzTa1505-hIgG4-S228P.

TABLE 8. Binding affinity of exemplary antibodies to tau-pS413 peptide

Antibody name	KD (M) mean	KD of HmzTa1505-hlgG4-S228P / KD (fold-change)
Ta1505-mIgG2a	9.40E-09	3.09
V0-hlgG1	2.43E-08	1.19
V0-hlgG4-S228P	3.93E-08	0.74
HmzTa1505-hlgG4-S228P	2.90E-08	1.00
V1-AFM-hlgG4-S228P	2.81E-09	10.31
V1-AFM-hlgG1-LALA	1.40E-09	20.66
V1-AFM-hlgG1-LALA-YTE	1.74E-09	16.67
V2-AFM-hlgG1-LALA	1.87E-09	15.51
V2-AFM-hlgG1-LALA-YTE	1.96E-09	14.80
V3-AFM-hlgG4-S228P	1.31E-08	2.22
V4-AFM-hlgG1-LALA	6.83E-09	4.25
V4-AFM-hlgG1-LALA-YTE	3.26E-09	8.89
V5-AFM-hlgG4-S228P	3.57E-09	8.12
V6-AFM-hlgG4-S228P	1.35E-09	21.43
V6-AFM-hlgG1-LALA	1.02E-09	28.50
V6-AFM-hlgG1-LALA-YTE	9.75E-10	29.77
V7-AFM-hlgG4-S228P	4.34E-09	6.69
V7-AFM-hlgG1-LALA	4.36E-09	6.65
V7-AFM-hlgG1-LALA-YTE	3.82E-09	7.59
V8-AFM-hlgG4-S228P	2.26E-09	12.81
V8-AFM-hlgG1-LALA	1.76E-09	16.52
V8-AFM-hlgG1-LALA-YTE	1.92E-09	15.13

Example 3. The high affinity anti-tau-pS413 antibodies bind specifically to tau peptide phosphorylated at serine 413

Binding specificity of the high affinity antibodies described herein was assessed with various tau peptides by a peptide-coated ELISA. Plates were coated with 50 µl of 1 µg/ml peptides 69AXY, 70AXY, 74AXY, 84AWK, 25AWF, or 24AWF in PBS for overnight at 4 °C. On the next day, the plates were washed 3 times, blocked with 200 µl of superblock for 1 hr at room temperature, then washed 3 times again. Antibodies were diluted at 1:5 serial dilution in ELISA buffer starting from 10 µg/ml. The plates were incubated with 50 µl of serially diluted antibodies at room temperature for 1 hr and washed 3 times. Then the plates were incubated with 50 µl of goat anti-mouse IgG-HRP (Southern Biotech, cat# 1030-05) or goat anti-human IgG-HRP (Jackson Immunologics, cat# 109-036-0980) diluted 1:3000 in ELISA buffer for 45 minutes at room temperature, washed 5 times, then developed with ABTS for 5 mins at room temperature and read at OD 405 nM.

The bindings of exemplary antibodies (V8-AFM-IgG1-LALA, V8-AFM-IgG1-LALA-YTE, V8-AFM-IgG4-S228P, V5-AFM-IgG4-S228P) are shown in **FIGS. 2A-2F**. For example, they all specifically bind to a tau peptide with phosphorylated serine 413 [PD17(p)PS413 (24AWF), SEQ ID NO:77] (**FIG. 2A**) but do not bind to the same peptide without phosphorylated serine 413, [PD17 (25AWF), SEQ ID NO:78] (**FIG. 2B**). Additionally, they do not bind to peptides that are phosphorylated at positions other than serine 413, such as pS396/400/404GC (84AWK, SEQ ID NO:79), pT212/pS214GC (69AXY, SEQ ID NO:80), T-pT217GC (70AXY, SEQ ID NO:82) or pSer412Cys (74AXY, SEQ ID NO:81) (**FIGS. 2C-2F**). A control antibody, humanized antibody against RSV does not bind to any of the tested peptides (**FIGS. 2A-2F**).

Example 4. Binding affinity of the high affinity anti-tau-pS413 antibodies to FcRn at pH 6 and pH 7.4

SPR assay was used to determine the binding affinity of the high affinity antibodies described herein to human and cynomolgus monkey (cyno) FcRn at pH 6.0 and 7.4. Anti-human kappa antibody was amine coupled to a CM5 chip. Each antibody was captured to 200-300 RUs. Binding assays were performed using PBS running buffer containing 0.05% Tween-20, adjusted to either pH 6.0 or 7.4. Titration samples were also prepared using the corresponding pH buffer for the assay. Titrating concentrations (1200 nM top, 6-point, 3-fold dilution series

and two zeros) of human or cyno FcRn were injected over the captured mAbs. Each sample injection was followed by two 30-second injections of 10 mM glycine, pH 1.5 and a 12-second injection of 10 mM NaOH to regenerate the surface for subsequent antibody capture and injection. All assays were run on Biacore T200 and / or 4000 instruments (GE Healthcare) and the data were fit to a steady-state approximation model using Biaevaluation software. Affinity at pH 6.0 was calculated as equivalent to concentration at half maximal binding signal in the steady-state approximation (**TABLE 9**). At pH 7.4, no binding was detectable as expected (data not shown).

Affinities for the high affinity anti-tau-pS413 antibodies at pH 6.0 were in a typical range for FcRn. Due to YTE mutation, V8-AFM-IgG1-LALA-YTE showed about 6.5- and about 11-fold higher affinities against human and cyno FcRn, respectively (**TABLE 9**).

TABLE 9. Binding affinities of anti-tau-pS413 antibodies to human and cyno FcRn

Antibody name	Human FcRn	Human FcRn fold change (relative to HmzTa1505-hIgG4-S228P)	Cyno FcRn	Cyno FcRn fold change (relative to HmzTa1505-hIgG4-S228P)
V8-AFM-hIgG1 LALA	2.3E-07	1	1.6E-07	1.6
V8-AFM-hIgG1 LALA-YTE	3.4E-08	6.5	2.4E-08	11
V8-AFM-hIgG4-S228P	2.1E-07	1	2.6E-07	1
HmzTa1505-hIgG4-S228P	2.2E-07	1	2.6E-07	1

Example 5. Binding affinities of the high affinity anti-tau-pS413 antibodies to brain homogenates and CSF samples from AD patients and preclinical models by competitive ELISA

Binding affinities of various anti-tau-pS413 antibodies described herein for endogenous tau species were determined in brain homogenates and CSF samples from AD patients and preclinical models. Briefly, samples were pre-incubated with different concentrations of various anti-tau-pS413 antibodies, or respective isotype controls. Following a one-hour pre-incubation period, the antigen-antibody (Ag-Ab) mixture was added to plates pre-coated with a total tau

capture antibody (Innotest ELISA kit). Unbound (“free”) tau-pS413 in the brain homogenate or CSF sample was then detected by biotinylated Ta1505-mIgG2a antibody.

P2 extracts (fractions) were prepared as follows. Ten grams of pre-frontal cortex tissue (ABS Inc) were immersed in artificial CSF buffer (aCSF: 119 mM NaCl, 2.5 mM KCl, 1 mM NaH₂PO₄, 1.3 mM MgSO₄, 2.5 mM CaCl₂, 26 mM NaHCO₃, 11 mM glucose, 10 mM HEPES, pH 7.4 and sterile water) with protease and phosphatase inhibitors (Pierce) at the dilution of tissue/buffer 1:5 (w/v). Tissue was homogenized by GentleMACS Dissociator. The lysed tissue was centrifuged at 3000 g for 20 minutes at 4 °C. The supernatants were transferred to polycarbonate 50 ml centrifuge tubes and spun at 27,000 g for 20 minutes at 4 °C. The supernatants were collected (S1 fraction) and further centrifuged at 150,000 g for 20 minutes at 4 °C. The pellets were resuspended, P2 fraction, in aCSF buffer with protease and phosphatase inhibitors and sonicated for a few seconds using a probe sonicator. The concentration of the P2 fraction was determined by BCA protein assay (Pierce) and the P2 fraction were aliquoted and stored at – 80 °C.

FIG. 3A illustrates the raw data showing the decreased levels of “free” unbound antigen in P2 extracts of AD brain homogenates with increasing concentrations of mAbs, but not isotype control. **FIG. 3B** illustrates the transformed data where the absorbance (OD) values of isotype control hIgG OD values (“total”) were subtracted from test mAbs (“free”) and normalized to calculate the occupancy EC₅₀’s of the profiled mAbs (**TABLE 10**). These studies demonstrate that representative high affinity anti-tau-pS413 antibodies binds to AD brain homogenates comparably, with significantly higher affinity than HmzTa1505-hIgG4-S228P.

TABLE 10. Binding affinity of anti-tau-pS413 antibodies to AD brain homogenates

Antibody name	EC ₅₀ (M)
HmzTa1505-hIgG4-S228P	6.50E-10
V1-AFM-hIgG4-S228P	3.23E-11
V1-AFM-hIgG1-LALA-YTE	3.10E-11
V2-AFM-hIgG1-LALA	3.90E-11
V3-AFM-hIgG4-S228P	2.55E-11
V5-AFM-hIgG4-S228P	3.10E-11
V6-AFM-hIgG4-S228P	2.23E-11
V7-AFM-hIgG1-LALA-YTE	4.10E-11
V8-AFM-hIgG1-LALA-YTE	2.60E-11
V8-AFM-hIgG1-LALA	2.60E-11
V8-AFM-hIgG4-S228P	2.50E-11

The high affinity anti-tau-pS413 antibodies described herein also bind to tau species in brain homogenates from mutant tau mice (rTg(tauP301L)4510) (Ramsden M et al., 2005, *J.Neurosci.* 25 (46) 10637-10647) and in the CSF from post-mortem AD patients and African Green Monkeys. Tissue homogenates were prepared using 1% sarkosyl buffer with several high-speed centrifugation steps to enrich for insoluble proteins including tau. Binding measures could not be assessed in CSF of the tau mutant mice because of the limited volume. The “effective” binding potencies of HmzTa1505-hIgG4-S228P and V8-AFM-hIgG1-LALA-YTE for the endogenous tau in the various biological specimens are about 2- to about 10-fold higher than the respective potencies for recombinant phosphorylated tau protein monomer used as standard (**TABLE 11**). These results suggest anti-tau-pS413 antibodies bind with an avidity component to the target tau species. The binding potencies of V8-AFM-hIgG1-LALA-YTE for these biological tau species are also about 30- to about 200-fold higher than those of HmzTa1505-hIgG4-S228P (**TABLE 11**).

TABLE 11. Binding potencies to tau species in brain homogenates and CSF samples from AD patients and preclinical models

Samples	Description	HmzTa1505-hIgG4-S228P EC50 (nM)	V8-AFM-hIgG1-LALA-YTE EC50 (nM)
phosphorylated tau protein monomer	35 AWM (1 ng)	6.73	0.055
AD brain	P2 high speed pellet (50 ng proteins)	0.65	0.022
Tau mutant mice brain	SI Tau seeds (4 ng protein)	0.67	0.004
AD post mortem CSF	AD patients (75 µl of neat CSF)	0.82 (average, n=3)	0.004 (average, n=2)
Fresh African Green Monkey (AGM) CSF	4 AGMs (75 µl of neat CSF)	2.08 (average, n=4)	0.008 (average, n=2)

Example 6. In vitro cellular potency of neutralization of seeding assay in hu-iPSC neurons

To evaluate and compare the activities of HmzTa1505-hIgG4-S228P and representative high affinity antibodies V1-AFM-hIgG4-S228P and V8-AFM-hIgG1-LALA-YTE in disease cellular system, a model of tau pathology seeding was developed in human iPSC-derived neurons using (P2) extracts from brain homogenates of AD patients. This neutralization assay consisted of immunodepleting Tau species from P2 AD brain homogenates with tau antibodies or isotype control before seeding the P2 extract in hu-iPSC neuronal culture. The immunodepletion was performed using Dynabeads protein G after pre-incubation of 4 µg of total protein of P2 extract with various concentration of mAbs or corresponding isotype control (3 nM to 3 pM) of tau antibodies or isotype control for 4 hours. Five days after treatment, neurons were immuno-stained with MC1 antibody, a tau mAb specific for pathological tau conformation (provided by Dr. Peter Davies, Department of Pathology, Albert Einstein College of Medicine). Tau pathology was quantified with high-content image analysis based on immuno-staining of MC1 antibody (Representative images in **FIG. 4D**). This neutralization assay consists of immunodepleting tau species from P2 extracts with HmzTa1505-hIgG4-S228P, V1-AFM-hIgG4-S228P, V8-AFM-hIgG1-LALA-YTE, or corresponding isotype control before seeding the P2 extract in hiPSC neurons (as described in the schematic representation of **FIG. 4A**).

The immuno-depleted samples were tested in AlphaLISA[®] assay to confirm the successful immuno-depletion of total tau (Tau5/HT7 antibody pair, **FIG. 4C**) or tau-pS413 species (pTa1505 IgG2a/HT7 antibody pair, **FIG. 4B**) with HmzTa1505-hIgG4-S228P, V1-AFM-hIgG4-S228P, or V8-AFM-hIgG1-LALA-YTE. Briefly, immunodepleted samples were incubated with HT7 (Thermofisher) acceptor beads (final concentration 20 µg/mL) and Tau5 (Thermofisher) or Ta1505 biotinylated antibody (0.6 µg/mL) for 2 hrs in immunoassay buffer at room temperature. Next, streptavidin donor beads (final concentration 40 µg/mL) were added to the plate and incubated for an additional 1 hr at room temperature with gentle shaking and then the plates were read on Envision plate reader (Perkin Elmer). Results demonstrated an effective pull-down of 70-90% of the tau-pS413 species and 50% of total tau species obtained with 0.1 nM of high affinity variant V1-AFM-hIgG4-S228P or V8-AFM-hIgG1-LALA-YTE *versus* 3 nM of HmzTa1505-hIgG4-S228P (**FIGS. 4B** and **4C**).

Five days after treatment, neurons were immuno-stained with MC1 antibody. High-content image analysis showed that neutralization with HmzTa1505-hIgG4-S228P, V1-AFM-hIgG4-S228P, or V8-AFM-hIgG1-LALA-YTE significantly decreased MC1 tau pathology in neurons; however, maximum inhibition ~70-90% of tau pathology was observed with 0.1 nM of high affinity variant V1-AFM-hIgG4-S228P or V8-AFM-hIgG1-LALA-YTE *versus* 3 nM of HmzTa1505-hIgG4-S228P (**FIG. 4E**). These results demonstrate that anti-tau-pS413 mAb can effectively recognize the toxic tau species found in the AD patient brains. In addition, the high affinity variants V1-AFM-hIgG4-S228P and V8-AFM-hIgG1-LALA-YTE are 30-fold more potent than HmzTa1505-hIgG4-S228P to neutralize the effects of the toxic tau species in inducing tau pathology in the human neuronal cell model.

Example 7. Efficacy of anti-tau-pS413 antibodies in an AD-derived tau hippocampal injection model using tau transgenic mice

Previous studies demonstrated a significant reduction in tau pathology following administration of Ta1505-mIgG2a with a trend towards decreases in pathology with increasing doses (see WO 2018/254390). The aim of this study was to determine if the murinized high affinity anti-tau-pS413 antibodies (e.g., V8-AFM-mIgG1), which showed a 40-fold increase binding potency for AD P2 brain extracts (0.013 nM for AFM-mIgG1 *versus* 0.51 nM for pTa1505, data not shown), was able to reduce tau pathology at lower doses than the parental antibody. An *in vivo* seeding model was used to evaluate the effect of Ta1505-mIgG1 (40 mg/kg, 10 mg/kg, 5 mg/kg), V8-AFM-mIgG1 (40 mg/kg, 10 mg/kg, 5 mg/kg, 1 mg/kg), or mIgG1 isotype control (40 mg/kg) on the development of tau pathology. Following the antibody treatment, Tg4510 mice (WT:Car) mice were injected into the hippocampus with Sarkosyl Insoluble (SI) Tau preparation from rTg(tauP301L)4510 mice (Car:Car) mice to elicit the transmission and of tau pathology around the injection site and spreading to other brain regions. Mice were then treated weekly with antibody injections. Thirty days after the initial dose, animals were necropsied and brain tissues were stained for tau hyperphosphorylated at amino acid positions S202 and T205 (AT-8 at a dilution of 1:1500 revealed with chromogenic staining). Tau pathology was evaluated in the injected region of the hippocampus. Seven sections of each animal's hippocampus were quantified by Halo software for % of positive staining per area.

FIG. 5 showed a reduced pathology with high doses of both V8-AFM-mIgG1 and Ta1505-mIgG1 and a trend towards a dose response reduction in tau pathology in the ipsilateral

hippocampus. While administration of V8-AFM-mIgG1 did not show significantly better reduction in tau pathology, drug exposures were unexpectedly lower in the V8-AFM-mIgG1 groups. In particular, for each dose level, the V8-AFM-mIgG1 group showed 20-fold lower PK levels than the Ta1505-mIgG1 group (**TABLE 12**). As a result, we could not directly compare the efficacious doses. However, at 40 mg/kg dose, a 35% reduction in pathology was observed for the V8-AFM-mIgG1 group at ~300 nM plasma levels whereas a 45% reduction was observed at 20-fold higher plasma exposure for Ta1505-mIgG1 (**TABLE 13**), suggesting the enhanced potency for the high affinity variant V8-AFM-mIgG1.

10 **TABLE 12. Plasma and CSF concentrations for mAb treatments groups at day 30**

Antibody name	Dose (mg/kg)	Plasma (nM)		CSF (nM)		CSF/plasma ratio
		Mean	SD	Mean	SD	
V8-AFM-mIgG1	40	307.8	157.4	0.30	0.23	0.10%
V8-AFM-mIgG1	10	116.7	76.3	0.35	0.65	0.30%
V8-AFM-mIgG1	5	41.5	48.4	0.06	0.02	0.144%
V8-AFM-mIgG1	1	38.8	45.8	BLQ	BLQ	BLQ
Ta1505-mIgG1	40	6203	786.4	6.05	3.70	0.098%
Ta1505-mIgG1	10	1558	383.3	1.21	0.50	0.078%
Ta1505-mIgG1	5	1019	315.5	1.28	1.79	0.13%

TABLE 13. Percentage of reduction in tau pathology

Treatment (antibody, dose)	Percent reduction from mIgG1 control
V8-AFM-mIgG1, 40 mg/kg	35%
V8-AFM-mIgG1, 10 mg/kg	22%
V8-AFM-mIgG1, 5 mg/kg	16%
V8-AFM-mIgG1, 1 mg/kg	14%
Ta1505-mIgG1, 40 mg/kg	45%
Ta1505-mIgG1, 10 mg/kg	20%
Ta1505-mIgG1, 5 mg/kg	-2%

15 **Example 8. Ex-vivo detection of target engagement by anti-tau-pS413 antibodies in CSF samples from healthy volunteers and AD patients**

An ultra-sensitive electro-chemiluminescent (ECL) assay on the Meso Scale Discovery S-Plex Platform was developed to measure a baseline level of tau-pS413 in human CSF and free

(i.e., unbound) tau-pS413 in the presence of tau-pS413-specific antibodies. The method can be used to demonstrate target engagement by anti-tau-pS413 antibodies as a reduction in free tau-pS413 signal. In this sandwich immunoassay, biotinylated mouse monoclonal anti-tau-pS413 antibody Ta1505 was coated onto MSD 96-well S-PLEX SECTOR Plates (Mesoscale Discovery, cat No. L45SA) at 1 µg/mL with 1x S-PLEX Coating Reagent C1 (Mesoscale Discovery Cat No C20H0). CSF samples were diluted 1:2 in Diluent 100 (Mesoscale Discovery Cat. No R50AA) with 0.12 mg/mL Heterophilic S Blocking Reagent 1 (Scantibodies Cat No. 3KC534-075). After washing the coated plate with 1x PBST, 75 µL samples were loaded per well in addition to 75 µL Diluent 100 with 1x S-PLEX Blocking Reagent S1 (Mesoscale Discovery Cat No. R93AG). Samples were incubated overnight at 4°C on an orbital shaker (700 rpm). After wash steps, the detection antibody, Turbo Boost-tagged Ta1505, was added to each well at 0.2 µg/mL in MSD Diluent 101 (Mesoscale Discovery Cat No. R51AD) and incubated for 1 hour at room temperature on orbital shaker (700 rpm). Color enhancement and development steps were performed following MSD S-PLEX protocol. Plates were read on MESO SECTOR™ S600 instrument for electro-chemiluminescent signal (A.U.).

The *ex-vivo* binding of anti-tau-pS413 antibody was evaluated by quantitating tau-pS413 after incubating human non-AD or AD CSF samples with V8-AFM-hIgG1-LALA-YTE at titrated concentrations (0.085 fM to 50 nM) using the tau-pS413 MSD S-PLEX assay. The assay signal reduced with increasing concentration of V8-AFM-hIgG1-LALA-YTE (**FIG. 7A**). The antibody reached 100% target occupancy at a concentration from about 1.85 nM to about 50 nM. The percent reduction of the free tau-pS413 (not bound by V8-AFM-hIgG1-LALA-YTE) levels was calculated based on a maximum signal produced without V8-AFM-hIgG1-LALA-YTE and a minimum signal produced without 50 nM V8-AFM-hIgG1-LALA-YTE (both the maximum level and the minimum level subtracted a background level without CSF samples but with the buffer only). The non-linear regression of the concentration-percent of reduction allows the determination of the *ex-vivo* potency of V8-AFM-hIgG1-LALA-YTE, $IC_{50} = 0.0169$ nM (95% confidence 0.0141 to 0.0204 nM), in CSF from AD patients (**FIG. 7B**). Due to the low tau-pS413 baseline signal and narrow reduction window in non-AD CSF samples, the $IC_{50} = 0.101$ nM in CSF from non-AD patients had a larger 95% confidence range (0.045 to 0.243 nM).

All references cited herein are incorporated by reference to the same extent as if each individual publication, database entry (e.g. GenBank sequences or GeneID entries), patent application, or patent, was specifically and individually indicated to be incorporated by

reference. This statement of incorporation by reference is intended by Applicants, pursuant to 37 C.F.R. §1.57(b)(1), to relate to each and every individual publication, database entry (e.g. GenBank sequences or GeneID entries), patent application, or patent, each of which is clearly identified in compliance with 37 C.F.R. §1.57(b)(2), even if such citation is not immediately adjacent to a dedicated statement of incorporation by reference. The inclusion of dedicated statements of incorporation by reference, if any, within the specification does not in any way weaken this general statement of incorporation by reference. Citation of the references herein is not intended as an admission that the reference is pertinent prior art, nor does it constitute any admission as to the contents or date of these publications or documents.

The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the invention in addition to those described herein will become apparent to those skilled in the art from the foregoing description and the accompanying figures. Such modifications are intended to fall within the scope of the appended claims.

The foregoing written specification is considered to be sufficient to enable one skilled in the art to practice the invention. Various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description and fall within the scope of the appended claims.

SEQUENCE LISTING

The present specification is being filed with a computer readable form (CRF) copy of Sequence Listing. The CRF entitled 24996WOPCT-SEQTXT-13MAY2021-ST25.txt, which was created on May 13, 2021 and is 113,797 bytes in size, is identical to the paper copy of the Sequence Listing and is incorporated herein by reference in its entirety. **TABLE 14** below summarizes all sequences disclosed in the specification.

TABLE 14. Sequences disclosed in the specification

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
1	Human tau isoform 4R2N	MAEPRQEFVME DHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKESPLQTP TEDGSEEPGSETSDAKSTPTAEDVTAPLVDEGA PGKQAAAPHT EIP EGT TAE EAG IGDTPSLEDEAAGHVTQAR MVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANA TRIPAKTPPAPKTPPSSGEPKSGDRSGYSSPGSPGTPGSR S

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		RTPSLPTPPPTREP KKVAVVRTPPKSPSSAKSRLQTAPVMPD LKNVSKIGSTENLKHQPGGGKVQI INKKLDLSNVQSKCGSK DNIKHVPGGGSVQIVYKPVDSLKVTSKCGSLGNIHHKPGGGQ VEVKSEKLDFKDRVQSKIGSLDNITHVPGGGNKKIETHKLT F RENAKAKTDHGAEIVYKSPVSGDTS PRHLSNVSTGSIDMV DSPQLATLADEV SASLAKQGL
2	Human tau isoform 4R1N	MAEPRQEFV MEDHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKESPLQTP TEDGSEEPGSETSDAKSTPTAEAE EAGIGDTPS LEDEAAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPR GAAPPGQKGQANATRIPAKTPPAPKTPPSSGEP PKSGDRSGY SSPGSPGTPGSRSRTPSLPTPPPTREP KKVAVVRTPPKSPSSA KSRLQTAPVMPD LKNVSKIGSTENLKHQPGGGKVQI INKK LDLSNVQSKCGSKDNIKHVPGGGSVQIVYKPVDSLKVTSKCG SLGNIHHKPGGGQVEVKSEKLDFKDRVQSKIGSLDNITHVPG GGNKKIETHKLT F RENAKAKTDHGAEIVYKSPVSGDTS PRH LSNVSTGSIDMV DSPQLATLADEV SASLAKQGL
3	Human tau isoform 4R0N	MAEPRQEFV MEDHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKAEEAGIGDTPSLEDEAAGHVTQARMVSKSKDGTGSDDKKA KGADGKTKIATPRGAAPPGQKGQANATRIPAKTPPAPKTPPS SGEP PKSGDRSGYSSPGSPGTPGSRSRTPSLPTPPPTREP KKV AVVRTPPKSPSSAKSRLQTAPVMPD LKNVSKIGSTENLKH QPGGGKVQI INKKLDLSNVQSKCGSKDNIKHVPGGGSVQIVY KPVDSLKVTSKCGSLGNIHHKPGGGQVEVKSEKLDFKDRVQS KIGSLDNITHVPGGGNKKIETHKLT F RENAKAKTDHGAEIVY KSPVSGDTS PRHLSNVSTGSIDMV DSPQLATLADEV SASL AKQGL
4	Human tau isoform 3R2N	MAEPRQEFV MEDHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKESPLQTP TEDGSEEPGSETSDAKSTPTAEDVTAPLVDEGA PGKQAAQPHTEIPEGTTAE EAGIGDTPSLEDEAAGHVTQAR MVSKSKDGTGSDDKKAKGADGKTKIATPRGAAPPGQKGQANA

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		TRIPAKTPPAPKTPPSSGEPPKSGDRSGYSSPGSPGTPGSR RTPSLPTPPTREPKKVAVVRTPPKSPSSAKSRLQTAPVMPD LKNVSKIGSTENLKHQPGGGKVQIVYKPVDSLKVTSKCGSL GNIHHKPGGGQVEVKSEKLDFKDRVQSKIGSLDNITHVPGGG NKKIETHKLTFRENAKAKTDHGAEIVYKSPVVGDTSPRHLS NVSTGSIDMVDS PQLATLADEV SASLAKQGL
5	Human tau isoform 3R1N	MAEPRQEFVEMDHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKESPLQTP TEDGSEEPGSETSDAKSTPTAEAE EAGIGDTPS LEDEAAGHVTQARMVSKSKDGTGSDDKKAKGADGKTKIATPR GAAPPGQKGQANATRIPAKTPPAPKTPPSSGEPPKSGDRSGY SSPGSPGTPGSRRTPSLPTPPTREPKKVAVVRTPPKSPSSA KSRLQTAPVMPD LKNVSKIGSTENLKHQPGGGKVQIVYK VDLSKVTSKCGSLGNIHHKPGGGQVEVKSEKLDFKDRVQSKI GSLDNITHVPGGGNKKIETHKLTFRENAKAKTDHGAEIVYKS PVVGDTSPRHLSNVSTGSIDMVDS PQLATLADEV SASLAK QGL
6	Human tau isoform 3R0N	MAEPRQEFVEMDHAGTYGLGDRKDQGGYTMHQDQEGD TDAG LKAEEAGIGDTPSLEDEAAGHVTQARMVSKSKDGTGSDDKKA KGADGKTKIATPRGAAPPGQKGQANATRIPAKTPPAPKTPPS SGEPPKSGDRSGYSSPGSPGTPGSRRTPSLPTPPTREPKKV AVVRTPPKSPSSAKSRLQTAPVMPD LKNVSKIGSTENLKH QPGGGKVQIVYKPVDSLKVTSKCGSLGNIHHKPGGGQVEVKS EKLDFKDRVQSKIGSLDNITHVPGGGNKKIETHKLTFRENAK AKTDHGAEIVYKSPVVGDTSPRHLSNVSTGSIDMVDS PQL ATLADEV SASLAKQGL
7	Ta1505, VL-CDR1	RSSQNIVHSNGNTYLE
8	Ta1505, VL-CDR2	TVSNRFS
9	Ta1505, VL-CDR3	FQGSHLPLT

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
10	Ta1505, VL	DIILMTQTPLSLPVSLGDQASISCRSSQNIVHSNGNTYLEWYL QKPGQSPKVLIIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSHLPLTFGGGTKELEK
11	Ta1505, light chain	DIILMTQTPLSLPVSLGDQASISCRSSQNIVHSNGNTYLEWYL QKPGQSPKVLIIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSHLPLTFGGGTKELEKRAAAPTVSIFPPS SEQLTSGGASVVCFLNNFYPKDINVKWKIDGSEKQNGVLNSW TDQDSKDSTYSMSSTLTTLTKDEYERHNSYTCEATHKTSTSPI VKSFNRNEC
12	Ta1505, VH-CDR1	SFALN
13	Ta1505, VH-CDR2	HIRSKTNNYATFYADSVKD
14	Ta1505, VH-CDR3	RGPRDSWFGY
15	Ta1505, VH	EVQLVESGGGLVQPKGSLKLSCAASGFAFNSFALNWVRQAPG KSLEWVWHIRSKTNNYATFYADSVKDRFTVSRDDSQSMVYLQ MNNLKTEDTGIYYCVRRGPRDSWFGYWGQGTLLTVSA
16	Ta1505, heavy chain	EVQLVESGGGLVQPKGSLKLSCAASGFAFNSFALNWVRQAPG KSLEWVWHIRSKTNNYATFYADSVKDRFTVSRDDSQSMVYLQ MNNLKTEDTGIYYCVRRGPRDSWFGYWGQGTLLTVSAAKTTA PSVYPLAPVCGDTTGSSTVTLGCLVKGYFPEPVTLTWNSGSL SGVHTFPAVLQSDLYTLSSSVTVTSSTWPSQSITCNVAHPAS STKVDKKIEPRGPTIKPCPPCKCPAPNLLGGPSVFI FPPKIK DVLMI SLSPIVTCVVDVSEDDPDVQISW FVNNVEVHTAQTQ THREDYNSTLRVVSALPIQH QDWM SGKEFKCKVNNKDL PAPI ERTISKPKGSVRAPQVYVLPPEEEMTKKQVTLTCMVTDFMP EDIYVEWTNNGKTELNYKNTEPVLDS DGSYFMYSKLRVEKKN WVERNSYSCSVVHEGLHNHHTTKSFSRTPGK
17	VL46, VL-CDR1	RSSQSI VHSNGNTYLE
18	VL46, VL-CDR2	TVSNRFS
19	VL46, VL-CDR3	FQGSHLPLT

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
20	VL46, VL	DIVMTQSPLSLPVTLGEPASISCRSSQSI VHSNGNTYLEWYL QKPGQSPQLLIYTVSNRFSGVPDRFSGSGSGTDFTLKISRVE AEDLGVIYCFQGS LPLTFGGGTKVEIK
21	VH11, VH-CDR1	SFALN
22	VH11, VH-CDR2	HIRSKTNNYATFYAASVKD
23	VH11, VH-CDR3	RGPRDSWFGY
24	VH11, VH	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSKTNNYATFYAASVKDRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGT LTVTVSS
25	VL46_G34A_S28N, VL-CDR1	RSSQNIVHSNANTYLE
26	VL46_G34A_S28N, VL-CDR2	TVSNRFS
27	VL46_G34A_S28N, VL-CDR3	FQGS LPLT
28	VL46_G34A_S28N, VL	DIVMTQSPLSLPVTLGEPASISCRSSQNIVHSNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVPDRFSGSGSGTDFTLKISRVE AEDLGVIYCFQGS LPLTFGGGTKVEIK
29	VL46_G34A_S28N_ Q27R_S32R_H98Y, VL-CDR1	RSSRNIVHRNANTYLE
30	VL46_G34A_S28N_ Q27R_S32R_H98Y, VL-CDR2	TVSNRFS
31	VL46_G34A_S28N_ Q27R_S32R_H98Y, VL-CDR3	FQGSYLPLT
32	VL46_G34A_S28N_ Q27R_S32R_H98Y, VL	DIVMTQSPLSLPVTLGEPASISCRSSRNIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVPDRFSGSGSGTDFTLKISRVE AEDLGVIYCFQGSYLPLTFGGGTKVEIK
33	VL46_G34A_S28K_ S32R_H98Y, VL- CDR1	RSSQKIVHRNANTYLE
34	VL46_G34A_S28K_ S32R_H98Y, VL- CDR2	TVSNRFS
35	VL46_G34A_S28K_ S32R_H98Y, VL- CDR3	FQGSYLPLT

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
36	VL46_G34A_S28K_S32R_H98Y, VL	DIVMTQSPLSLPVTLGEPASISCRSSQKIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSYLPLTFGGGTKVEIK
37	VL46_G34A_S28N_Q27H_S32R_H98Y, VL-CDR1	RSSHNIIVHRNANTYLE
38	VL46_G34A_S28N_Q27H_S32R_H98Y, VL-CDR2	TVSNRFS
39	VL46_G34A_S28N_Q27H_S32R_H98Y, VL-CDR3	FQGSYLPLT
40	VL46_G34A_S28N_Q27H_S32R_H98Y, VL	DIVMTQSPLSLPVTLGEPASISCRSSHNIIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSYLPLTFGGGTKVEIK
41	VH11_D68G, VH-CDR1	SFALN
42	VH11_D68G, VH-CDR2	HIRSKTNNYATFYAASVKG
43	VH11_D68G, VH-CDR3	RGPRDSWFGY
44	VH11_D68G, VH	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSKTNNYATFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTTLTVSS
45	VH11_A59V_D68G, VH-CDR1	SFALN
46	VH11_A59V_D68G, VH-CDR2	HIRSKTNNYVTFYAASVKG
47	VH11_A59V_D68G, VH-CDR3	RGPRDSWFGY
48	VH11_A59V_D68G, VH	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSKTNNYVTFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTTLTVSS
49	VH11_K54E_D68G, VH-CDR1	SFALN
50	VH11_K54E_D68G, VH-CDR2	HIRSETNNYATFYAASVKG
51	VH11_K54E_D68G, VH-CDR3	RGPRDSWFGY
52	VH11_K54E_D68G, VH	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSETNNYATFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTTLTVSS
53	VH11_K54E_A59V_D68G, VH-CDR1	SFALN

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
54	VH11_K54E_A59V_D68G, VH-CDR2	HIRSETNNYVTFYAASVKG
55	VH11_K54E_A59V_D68G, VH-CDR3	RGPRDSWFGY
56	VH11_K54E_A59V_D68G, VH	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSETNNYVTFYAASVKGRTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTLLTVSS
57	Human lambda light chain, constant region	GQPKANPTVTLFPPSSEELQANKATLVCLISDFYPGAVTVAV KADGSPVKAGVETTKPSKQSNKYAASSYLSLTPEQWKSHRS YSCQVTHEGSTVEKTVAPTECS
58	Human kappa light chain, constant region	RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWK VDNALQSGNSQESVTEQDSKDYSLSTLTLSKADYEKHKV YACEVTHQGLSSPVTKSFNRGEC
59	Human_IgG1 heavy chain, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTQSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLF PPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVH NAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA LPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLT VDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK
60	Human_IgG1_LALA, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTQSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEaaGGPSVFLF PPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVH NAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA LPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		KGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
61	Human_IgG1_LALA_D265S, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEaaGGPSVFLF PPKPKDTLMISRTPEVTCVVsVSHEDPEVKFNWYVDGVEVH NAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA LPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
62	Human_IgG1_YTE, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLF PPKPKDTLyItRePEVTCVVVDVSHEDPEVKFNWYVDGVEVH NAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA LPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
63	Human_IgG1_LALA_YTE, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEaaGGPSVFLF PPKPKDTLyItRePEVTCVVVDVSHEDPEVKFNWYVDGVEVH NAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA LPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLV KGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
64	Human_IgG1_N297A, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICN

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		VNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYASTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
65	Human_IgG1_N297 Q, constant region	ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTWSN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYqSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
66	Human_IgG2, constant region	ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTWSN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSNFGTQTYTCNVDHKPSNTKVDKTVKCCVECPAPPVAGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTFRVSVLTVVHQDWLNGKEYKCKVSNKGLPAPIEKTISKTKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDISVEWESNGQPENNYKTTTPMLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
67	Human_IgG4, constant region	ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTWSN SGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYTCNVDHKPSNTKVDKRVESKYGPPCPSCPAPEFLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSDQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSLSLGK

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
68	Human_IgG4_S228P , constant region	ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWN SGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGKTYTCN VDHKPSNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPK PKDTLMISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAK TKPREEQFNSTYRVSVLTVHLQDNLNGKEYKCKVSNKGLPS SIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGF YPSDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSRLTVDK SRWQEGNVFSCSVMEALHNHYTQKSLSLSLGK
69	VL46_G34A_S28N_ kappa light chain	DIVMTQSPLSLPVTLGEPASISCRSSQNIVHSNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVIYCFQGSYLPPLTGGGTKEIKRTVAAPSVFIFPPS DEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESV TEQDSKDSSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPV TKSFNRGEC
70	VH11_IgG4-S228P heavy chain	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIIRSKTNNYATFYAASVKDRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTILVTVSSASTKG PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALT SGVHTFPAVLQSSGLYSLSSVTVPSSSLGKTYTCNVDHKP SNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTL MISRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPRE EQFNSTYRVSVLTVHLQDNLNGKEYKCKVSNKGLPSSIEKT ISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDI AVEWESNGQPENNYKTTTPVLDSDGSFFLYSRLTVDKSRWQE GNVFSCSVMEALHNHYTQKSLSLSLGK
71	V8-AFM-hIgG1 LALA, light chain	DIVMTQSPLSLPVTLGEPASISCRSSQKIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVIYCFQGSYLPPLTGGGTKEIKRTVAAPSVFIFPPS DEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESV

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		TEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPV TKSFNRGEC
72	V8-AFM-hIgG1 LALA, heavy chain	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSETNNYVTFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTLLTVSSASTKG PSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALT SGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKP SNTKVDKKVEPKSCDKTHTCPPCPAPEaaGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTK PREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPI EKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYP SDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
73	V8-AFM-hIgG1 LALA YTE, light chain	DIVMTQSPLSLPVTLGEPASISCRSSQKIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFGVPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSYLPLTFGGGTKEIKRTVAAPSVFIFPPS DEQLKSGTASVVCCLNNFYPREAKVQWKVDNALQSGNSQESV TEQDSKDSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPV TKSFNRGEC
74	V8-AFM-hIgG1 LALA YTE, heavy chain	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSETNNYVTFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTLLTVSSASTKG PSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALT SGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKP SNTKVDKKVEPKSCDKTHTCPPCPAPEaaGGPSVFLFPPKPK DTLyItRePEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTK PREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPI EKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYP SDIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

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75	V8-AFM-hIgG4, light chain	DIVMTQSPLSLPVTLGEPASISCRSSQKIVHRNANTYLEWYL QKPGQSPQLLIYTVSNRFSGVDPDRFSGSGSGTDFTLKISRVE AEDLGVYYCFQGSYLPLTFGGGTKEIKRTVAAPSVFIFPPS DEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESV TEQDSKDSYSTLSSTLTLSKADYEKHKVYACEVTHQGLSSPV TKSFNRGEC
76	V8-AFM-hIgG4, heavy chain	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSFALNWVRQAPG KGLEWVGHIRSETNNYVTFYAASVKGRFTVSRDDSQNTAYLQ MNSLKTEDTATYYCVRRGPRDSWFGYWGQGTLLTVVSSASTKG PSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALT SGVHTFPAVLQSSGLYSLSSVTVPSSSLGTKTYTCNVDHKP SNTKVDKRVESKYGPPCPPCPAPEFLGGPSVFLFPPKPKDTL MISRTPEVTCVVVDVSDQEDPEVQFNWYVDGVEVHNAKTKPRE EQFNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKGLPSSIEKT ISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDI AVEWESNGQPENNYKTTTPVLDSDGSFFLYSRLTVDKSRWQE GNVFSCSVMEALHNHYTQKSLSLGLK
77	PD17(P)	PRHLSNVS (pS) TGSIDMVD
78	PD17	PRHLSNVSSTGSIDMVD
79	T-pS396/400/404GC	GCRENAKAKTDHGAEIVYK (pS) PVV (pS) GDT (pS) PRHL
80	T-pT212pS214GC	GCGSPGTPGSRSR (pT) P (pS) LPTPPTREPK
81	pSer412Cys	NV (pS) STGSC
82	T-pT217GC	GCGSRSRTPSLP (pT) PPTREPKKVAVV
83	VL-CDR1, AbM	RSSQKIVHRNANTYLE
84	VL-CDR2, AbM	TVSNRFS
85	VL-CDR3, AbM	FQGSYLPLT
86	VH-CDR1, AbM	GFTFSSFALN
87	VH-CDR2, AbM	HIRSETNNYVTF
88	VH-CDR3, AbM	RGPRDSWFGY
89	VL-CDR1, Chothia	RSSQKIVHRNANTYLE

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90	VL-CDR2, Chothia	TVSNRFS
91	VL-CDR3, Chothia	FQGSYLPLT
92	VH-CDR1, Chothia	GFTFSSF
93	VH-CDR2, Chothia	RSETNNYV
94	VH-CDR3, Chothia	RGPRDSWFGY
95	VL-CDR1, Contact	VHRNANTYLEWY
96	VL-CDR2, Contact	LLIYTVSNRF
97	VL-CDR3, Contact	FQGSYLPL
98	VH-CDR1, Contact	SSFALN
99	VH-CDR2, Contact	WVGHIRSETNNYVTF
100	VH-CDR3, Contact	VRRGPRDSWFG
101	VL-CDR1, IMGT	QKIVHRNANTY
102	VL-CDR2, IMGT	TV
103	VL-CDR3, IMGT	FQGSYLPLT
104	VH-CDR1, IMGT	GFTFSSFA
105	VH-CDR2, IMGT	IRSETNNYV
106	VH-CDR3, IMGT	VRRGPRDSWFGY
107	DNA encoding light chain	atgtccgtgcctacacaggttctgggactgctgctgctgtgg ctgaccgacgccagatgcgacatcgtgatgaccagtcctcca ctgagcctgacctgtgacactgggagagccagcctccatctcc tgccggctcctctcagaaaatcgtgcaccggaacgccaacacc tacctggaatggatctctgcagaagcccgccagtcctcctcag ctgctgatctacaccgtgtccaaccggttctctggcgtgccc gatagattctccggctctggctctggcaccgacttcaccctg aagatctccagagtggaagccgaggacctgggctgtactac tgcttccaaggctcctacctgcctctgacctttggcggcgga acaaaggtggaaatcaagcggacagtggccgctccttccgtg ttcatcttcccaccttccgacgagcagctgaagtccggcaca gcttctgtcgtgtgcctgctgaacaacttctaccctcgggaa gccaaaggtgcagtgggaaggtggacaatgcctgcagtcgggc

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		aactcccaagagtctgtgaccgagcaggactccaaggacagc acctacagcctgtcctccacactgaccctgtccaaggccgac tacgagaagcacaaggtgtacgcctgcgaagtgacccatcag ggcctgtctagccctgtgaccaagtctttcaaccggggcgag tgt
108	DNA encoding heavy chain	atggaatggctcctgggtgttcctgttcttctcctgtccgtgacc accggcgtgcactctgaagtgcagctggttgaatctggcggc ggattggttcagcctggcggatctctgagactgtcttgtgcc gcctccggcttcaccttctctagcttcgctctgaactgggtc cgacaggctcctggcaaaggactggaatgggtcggacacatc agatccgagacaaacaactacgtgaccttctacgccgccagc gtgaagggcagattcaccgtgtccagagatgactcccagaac accgcctacctgcagatgaactccctgaaaaccgaggacacc gccacctactactgcgtgcgaagaggccctcgggacagttgg ttcggatattggggacagggcacccctcgtgaccgtgtcctct gcttctaccaagggacccagcgtgttccctctggctccttcc agcaagtctacctctggcggaacagctgctctgggctgcctg gtcaaggactactttcctgagcctgtgacagtgtcctggaac tctggcgctctgacatctggcgtgcacacctttccagctgtg ctgcagtccctccggcctgtactctctgtcctctgtcgtgaca gtgccctccagctctctgggaaccagacctacatctgcaat gtgaaccacaagccttccaacaccaaggtggacaagaaggtg gaaccaagtccctgcgacaagaccacacctgtcctccatgt cctgctccagaagctgctggcgcccttccgtgtttctgttc cctccaaagcctaaggacaccctgtacatcaccgcgagcct gaagtgacctgcgtggtggtggatgtgtctcacgaggacccc gaagtgaagttcaattggtacgtggacggcgtggaagtgcac aacgccaagaccaagcctagagaggaacagtacaactccacc tacagagtgggtgtccgtgctgaccgtgctgcaccaggattgg ctgaacggcaaagagtacaagtgcaaggtgtccaacaaggcc

SEQ ID NO	Sequence Description	Sequence (SEQ ID NO:107 and 108 are nucleotide sequences, the rest are amino acid sequences)
		ctgcctgctcctatcgaaaagaccatctccaaggccaagggc cagcctaggggaaccccaggtttacaccttgcctccatctcgg gacgagctgaccaagaaccagggtgtccctgacctgcctcgtg aagggattctaccctccgatatcgccgtggaatgggagtct aatggccagcctgagaacaactacaagacaacccctcctgtg ctggactccgacggctcattctttctgtactccaagctgaca gtggacaagtccagatggcagcagggcaacgtgttctcctgc agcgtgatgcacgaggccctgcacaatcactacaccagaag tcctgtctctgtccctggcaaa
109	Peptide	GAEIVYK (pS) PVVSGDT (pS) PRHLSNVS (pS) TGSIDMVD (pS) PQLATLADEVASLAKQGL