

METHODS OF DETECTING TRANSTHYRETIN

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 USC 119(e) of U.S. Provisional Application No. 62/569,438, filed October 6, 2017, of U.S. Provisional Application No. 62/579,817, filed October 31, 2017, and of U.S. Provisional Application No. 62/647,582, filed March 23, 2018, each of which is incorporated by reference in its entirety for all purposes.

REFERENCE TO A SEQUENCE LISTING

[0002] The Sequence Listing written in file 516713SEQLIST.txt is 61.8 kilobytes, was created on September 20, 2018, and is hereby incorporated by reference.

BACKGROUND

[0003] Several diseases are thought to be caused by the abnormal folding and aggregation of disease-specific proteins. These proteins can accumulate into pathologically diagnostic accumulations, known as amyloids, which are visualized by certain histologic stains. Amyloids are thought to elicit inflammatory responses and have multiple negative consequences for the involved tissues. In addition, smaller aggregates of abnormally folded protein may exist and exert cytotoxic effects.

[0004] Transthyretin (TTR) is one of the many proteins that are known to misfold and aggregate (*e.g.*, undergo amyloidogenesis). Transthyretin-mediated amyloidosis (ATTR) encompasses two forms of disease: familial disease arising from misfolding of a mutated or variant TTR, and a sporadic, non-genetic disease caused by misfolding and aggregation of wild-type TTR. The process of TTR amyloidogenesis can cause pathology in the nervous system and/or heart, as well as in other tissues.

SUMMARY OF THE CLAIMED INVENTION

[0005] In one aspect, the invention provides a method of detecting misfolded transthyretin (TTR) in a biological sample, the method comprising: (a) contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and (b) detecting the reporter antibody that forms a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0006] In some such methods, the biological sample is from a hereditary ATTR patient. In some such methods, the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, G47R, S50I, T49S, F33V, A45T, E89K, E89Q, and V122I. In some such methods, the mutation is selected from the group consisting of V30M, Y114C, and S50I. In some such methods, the mutation is V30M. In some such methods, the mutation is Y114C. In some such methods, the mutation is S50I. In some such methods, the mutation is E89K. In some such methods, the mutation is E89Q.

[0007] In some such methods, the capture antibody is 9D5. In some such methods, the capture antibody is 9D5 and the reporter antibody is a polyclonal anti-TTR antibody. In some such methods, the reporter antibody is 18C5, 8C3, 7G7, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof, or a polyclonal anti-TTR antibody.

[0008] In some such methods, the capture antibody is 9D5 and the reporter antibody is 18C5, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is 8C3, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is 7G7, or a chimeric version or humanized version thereof.

[0009] In some such methods, the capture antibody is 9D5 and the reporter antibody is AD7F6, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is RT24, or a chimeric version or humanized version thereof. In

some such methods, the capture antibody is 9D5 and the reporter antibody is NI-301.35G11, or a chimeric version or humanized version thereof.

[0010] In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD101, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD102, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD103, In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD105, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD107, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD108, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD109, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD111, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 9D5 and the reporter antibody is MFD114, or a chimeric version or humanized version thereof.

[0011] In some such methods, the reporter antibody is an antibody that binds within residues 101-109, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or 115-127 of TTR.

[0012] Some such methods detect misfolded TTR including an E89K substitution. Some such methods detect misfolded TTR including an E89Q substitution.

[0013] In some such methods, the biological sample is a first aliquot of a collected sample and the method further comprises repeating step (a) and (b) on a second aliquot of the collected sample further comprising a test antibody that competes with the capture antibody for binding to TTR, wherein reduced reporter antibody forming the sandwich complex on repeating the steps provides an indication of the test antibody's ability to bind to misfolded TTR.

[0014] In some such methods, the test antibody is 14G8 or a chimeric or humanized form thereof, the capture antibody is 9D5, and the reporter antibody is a polyclonal anti-TTR antibody. In some such methods, the test antibody is a humanized form of 14G8.

[0015] In another aspect, the invention provides a method of determining in vivo target engagement of a test antibody administered to a subject, which target is an epitope within residues 89-97 of misfolded transthyretin (mis-TTR) by detecting the mis-TTR remaining in a biological sample from the subject treated with the test antibody, the method comprising: (a) contacting the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 and a reporter antibody that specifically binds to a different epitope within TTR from that of the capture antibody; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and (b) detecting the reporter antibody forming a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0016] In some such methods, the biological sample is from a hereditary ATTR patient. In some such methods, the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, G47R, S50I, T49S, F33V, A45T, E89K, E89Q, and V122I. In some such methods, the mutation is selected from the group consisting of V30M, Y114C, and S50I. In some such methods, the mutation is V30M. In some such methods, the mutation is Y114C. In some such methods, the mutation is S50I. In some such methods, the mutation is E89K. In some such methods, the mutation is E89Q.

[0017] In some such methods, a reduction of detection of misfolded TTR in the treated subject relative to the detection of misfolded TTR in a biological sample from an untreated subject correlates with positive target engagement and treating the subject with the same or a lesser amount of the test antibody. In some such methods, the treated subject and the untreated subject are the same individual.

[0018] In some such methods, the capture antibody is 9D5 and the reporter antibody is 9D5, wherein the capture antibody and the reporter antibody have different labels. In some such methods, the capture antibody is 9D5 and the reporter antibody is 14G8. In some such methods, the capture antibody is 9D5 and the reporter antibody is 5A1. In some such methods, the capture

antibody is 9D5 and the reporter antibody is 6C1. In some such methods, the reporter antibody competes for binding with the capture antibody for binding multimeric misfolded transthyretin.

[0019] In some embodiments, the reporter antibody has an electrochemiluminescent label and is detected by electrochemiluminescence. In some methods of the invention, the capture antibody has a biotin label.

[0020] In an embodiment, the methods are performed qualitatively. In an embodiment, the methods are performed quantitatively to indicate an absolute or relative amount of the misfolded TTR.

[0021] In some such methods, the capture antibody is bound to a solid phase before the contacting step. In some such methods, the capture antibody is attached to the solid phase via a linker. In some such methods, the solid phase comprises at least one electrode.

[0022] Some such methods further comprise comparing a signal from the reporter antibody with a signal from the reporter antibody in a control sample containing a known amount of misfolded TTR to determine the amount of misfolded TTR in the sample.

[0023] Some such methods further comprise comparing a signal from the reporter antibody from a calibration curve of signal versus amount of misfolded TTR to determine the amount of misfolded TTR in the sample. In some such methods, a signal from the reporter antibody is proportional to the amount of misfolded TTR in the sample.

[0024] In some such methods, the sample is a sample from a human. In some such methods, the sample is a body fluid. In some such methods, the sample is plasma of a human.

[0025] In an embodiment, the presence of misfolded TTR is used to diagnose a subject from whom the sample was obtained with a transthyretin-mediated amyloidosis. In an embodiment, the transthyretin-mediated amyloidosis is a familial transthyretin amyloidosis or a sporadic wild-type transthyretin amyloidosis. In an embodiment, the subject has been identified as at risk of a familial transthyretin amyloidosis based on genetic testing.

[0026] In an embodiment, the subject does not show symptoms of a familial transthyretin amyloidosis. In an embodiment, the subject does not have polyneuropathy or cardiomyopathy.

[0027] In an embodiment, the familial transthyretin amyloidosis is familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA).

[0028] In an embodiment, the biological sample is from a patient receiving treatment for a transthyretin-mediated amyloidosis.

[0029] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising comparing the amount of misfolded TTR detected in the subject previously treated for transthyretin mediated amyloidosis with the amount of misfolded TTR detected in the subject prior to treatment or during an earlier stage of treatment; and (a) increasing the dose or frequency of administration of the prior treatment if the amount of misfolded TTR is the same or greater than that previously detected; or (b) decreasing the dose or frequency of administration of the prior treatment or discontinuing the prior treatment if the amount of misfolded TTR is less than that previously detected. In an embodiment, the misfolded TTR is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0030] In some such methods, the prior treatment is by intravenous administration of an anti-TTR antibody and if the amount of misfolded TTR is less than that previously detected, the prior treatment is discontinued and replaced with treatment with a TTR stabilizer, antisense oligonucleotide based therapy, RNA interference therapy or combination therapy with doxycycline and tauroursodeoxycholic acid. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0031] In some such methods, the anti-TTR antibody is 14G8. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0032] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising (a) comparing the amount of reporter antibody binding in a sample from a subject before initiating treatment for transthyretin mediated amyloidosis with the amount of reporter antibody binding detected in the subject after initiating treatment; and (b) increasing the dose or frequency of administration of the treatment if the amount of reporter antibody binding is the same or greater than that previously detected; or (c) decreasing the dose or frequency of administration of the treatment or discontinuing the treatment if the amount of reporter antibody binding is less than that previously detected. In an embodiment, the reporter antibody binding is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0033] In some methods, a transthyretin-mediated amyloidosis is distinguished from amyloid light-chain (AL) amyloidosis. In some methods, the sample is from a transgenic mouse with a transgene expressing human TTR.

[0034] In another aspect, the invention provides a method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample; the method comprising:

- (a) dividing a biological sample into two portions;
- (b) detecting total misfolded TTR in a first portion of the biological sample by

(i) contacting the first portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody forming a sandwich complex in step (b)(i), if any, to indicate presence or absence of the misfolded TTR;

(c) detecting total multimeric misfolded TTR in a second portion of the biological sample by

(i) contacting the second portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 and a reporter antibody that specifically binds to an epitope within residues 89-97 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody forming a sandwich complex in step (c)(i), if any, to indicate presence or absence of the multimeric misfolded TTR.

(d) calculating a ratio of the level of total multimeric misfolded TTR of (c) to the level of total misfolded TTR of (b).

[0035] In one aspect, the invention provides a method of detecting misfolded transthyretin (TTR) in a biological sample, the method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0036] In some such methods, the capture antibody is 18C5. In some such methods, the capture antibody is 18C5 and the reporter antibody is a polyclonal anti-TTR antibody. In some such methods, the reporter antibody is 9D5, 14G8, 5A1, 6C1, 8C3, 7G7, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof.

[0037] In some such methods, the capture antibody is 18C5 and the reporter antibody is 9D5, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 14G8, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 5A1, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 6C1, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 8C3, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 7G7, or a chimeric version or humanized version thereof.

[0038] In some such methods, the capture antibody is 18C5 and the reporter antibody is AD7F6, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is RT24, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is NI-301.35G11, or a chimeric version or humanized version thereof.

[0039] In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD101, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MDF102, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD103, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD105, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD107, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD108, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and

the reporter antibody is MFD109, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD111, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD114, or a chimeric version or humanized version thereof.

[0040] In some such methods, the reporter antibody is an antibody that binds within residues 89-97, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or 115-127 of TTR.

[0041] In another aspect, the invention provides a method of detecting multimeric misfolded transthyretin (TTR) in a biological sample, the method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a reporter antibody that specifically binds to an epitope within residues 101-109 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the multimeric misfolded TTR in step (a), if any, to indicate presence or absence of the multimeric misfolded TTR.

[0042] In some such methods, the capture antibody is 18C5 and the reporter antibody is 18C5, wherein the capture antibody and the reporter antibody have different labels. In some such methods, the reporter antibody competes for binding with the capture antibody for binding multimeric misfolded transthyretin.

[0043] In some embodiments, the reporter antibody has an electrochemiluminescent label and is detected by electrochemiluminescence. In some methods of the invention, the capture antibody has a biotin label.

[0044] In an embodiment, the methods are performed qualitatively. In an embodiment, the methods are performed quantitatively to indicate an absolute or relative amount of the misfolded TTR.

[0045] In some such methods, the capture antibody is bound to a solid phase before the contacting step. In some such methods, the capture antibody is attached to the solid phase via a linker. In some such methods, the solid phase comprises at least one electrode.

[0046] Some such methods further comprise comparing a signal from the reporter antibody with a signal from the reporter antibody in a control sample containing a known amount of misfolded TTR to determine the amount of misfolded TTR in the sample.

[0047] Some such methods further comprise comparing a signal from the reporter antibody from a calibration curve of signal versus amount of misfolded TTR to determine the amount of misfolded TTR in the sample. In some such methods, a signal from the reporter antibody is proportional to the amount of misfolded TTR in the sample.

[0048] In some such methods, the sample is from a human. In some such methods, the sample is a body fluid. In some such methods, the sample is plasma of a human.

[0049] In an embodiment, the presence of misfolded TTR is used to diagnose a subject from whom the sample was obtained with a transthyretin-mediated amyloidosis. In an embodiment, the transthyretin-mediated amyloidosis is a familial transthyretin amyloidosis or a sporadic wild-type transthyretin amyloidosis. In an embodiment, the subject has been identified as at risk of a familial transthyretin amyloidosis based on genetic testing.

[0050] In an embodiment, the subject does not show symptoms of a familial transthyretin amyloidosis. In an embodiment, the subject does not have polyneuropathy or cardiomyopathy.

[0051] In an embodiment, the familial transthyretin amyloidosis is familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA).

[0052] In an embodiment, the biological sample is from a patient receiving treatment for a transthyretin-mediated amyloidosis.

[0053] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising comparing the amount of misfolded TTR in a sample from a subject previously treated for transthyretin mediated amyloidosis with the amount of misfolded TTR detected in the subject prior to treatment or during an earlier stage of treatment; and increasing the dose or frequency of administration of the prior treatment if the amount of misfolded TTR is the same or greater than that previously detected; or decreasing the

dose or frequency of administration of the prior treatment or discontinuing the prior treatment if the amount of misfolded TTR is less than that previously detected. In an embodiment, the misfolded TTR is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0054] In some such methods, the prior treatment is by intravenous administration of an anti-TTR antibody and if the amount of misfolded TTR is less than that previously detected, the prior treatment is discontinued and replaced with treatment with a TTR stabilizer, antisense oligonucleotide based therapy, RNA interference therapy or combination therapy with doxycycline and tauroursodeoxycholic acid. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0055] In some such methods, the anti-TTR antibody is 14G8. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0056] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising (a) comparing the amount of reporter antibody binding in a sample from a subject before initiating treatment for transthyretin mediated amyloidosis with the amount of reporter antibody binding detected in the subject after initiating treatment; and (b) increasing the dose or frequency of administration of the treatment if the amount of reporter antibody binding is the same or greater than that previously detected; or (c) decreasing the dose or frequency of administration of the treatment or discontinuing the

treatment if the amount of reporter antibody binding is less than that previously detected. In an embodiment, the reporter antibody binding is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0057] In some methods, a transthyretin-mediated amyloidosis is distinguished from amyloid light-chain (AL) amyloidosis. In some methods, the sample is from a transgenic mouse with a transgene expressing human TTR.

[0058] In another aspect, the invention provides a method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample; the method comprising:

- (a) dividing a biological sample into two portions;
- (b) detecting total misfolded TTR in a first portion of the biological sample by
 - (i) contacting the first portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and
 - (ii) detecting the reporter antibody bound to the misfolded TTR in step (i), if any, to indicate presence or absence of the misfolded TTR;
- (c) detecting total multimeric misfolded TTR in a second portion of the biological sample by
 - (i) contacting the second portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a

reporter antibody that specifically binds to an epitope within residues 101-109 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody bound to the multimeric misfolded TTR in step (a), if any, to indicate presence or absence of the multimeric misfolded TTR.

(d) calculating a ratio of the level of total multimeric misfolded TTR of (c) to the level of total misfolded TTR of (b).

[0059] In one aspect, the invention provides a method of detecting misfolded transthyretin (TTR) in a biological sample, the method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0060] In some such methods, the biological sample is from a hereditary ATTR patient. In some such methods, the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, and S50I. In some such methods, the mutation is V30M. In some such methods, the mutation is Y114C. In some such methods, the mutation is S50I.

[0061] In some such methods, the capture antibody is 18C5. In some such methods, the capture antibody is 18C5 and the reporter antibody is a polyclonal anti-TTR antibody. In some such methods, the reporter antibody is 9D5, 14G8, 5A1, 6C1, 8C3, 7G7, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof.

[0062] In some such methods, the capture antibody is 18C5 and the reporter antibody is 9D5, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 14G8, or a chimeric version or humanized version thereof. In

some such methods, the capture antibody is 18C5 and the reporter antibody is 5A1, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 6C1, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 8C3, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is 7G7, or a chimeric version or humanized version thereof.

[0063] In some such methods, the capture antibody is 18C5 and the reporter antibody is AD7F6, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is RT24, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is NI-301.35G11, or a chimeric version or humanized version thereof.

[0064] In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD101, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MDF102, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD103, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD105, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD107, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD108, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD109, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD111, or a chimeric version or humanized version thereof. In some such methods, the capture antibody is 18C5 and the reporter antibody is MFD114, or a chimeric version or humanized version thereof.

[0065] In some such methods, the reporter antibody is an antibody that binds within residues 89-97, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or 115-127 of TTR.

[0066] In one aspect, the invention provides a method of determining in vivo target engagement of a test antibody administered to a subject, which target is an epitope within residues 101-109 of misfolded transthyretin (mis-TTR) by detecting the mis-TTR remaining in a biological sample from the subject treated with the test antibody, the method comprising: (a) contacting the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a reporter antibody that specifically binds to a different epitope within TTR from that of the capture antibody; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and (b) detecting the reporter antibody forming a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0067] In some such methods, the biological sample is from a hereditary ATTR patient. In some such methods, the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, and S50I. In some such methods, the mutation is V30M. In some such methods, the mutation is Y114C. In some such methods, the mutation is S50I.

[0068] In some such methods, the capture antibody is 18C5, wherein the capture antibody and the reporter antibody have different labels. In some such methods, the reporter antibody competes for binding with the capture antibody for binding multimeric misfolded transthyretin.

[0069] In some embodiments, the reporter antibody has an electrochemiluminescent label and is detected by electrochemiluminescence. In some methods of the invention, the capture antibody has a biotin label.

[0070] In an embodiment, the methods are performed qualitatively. In an embodiment, the methods are performed quantitatively to indicate an absolute or relative amount of the misfolded TTR.

[0071] In some such methods, the capture antibody is bound to a solid phase before the contacting step. In some such methods, the capture antibody is attached to the solid phase via a linker. In some such methods, the solid phase comprises at least one electrode.

[0072] Some such methods further comprise comparing a signal from the reporter antibody with a signal from the reporter antibody in a control sample containing a known amount of misfolded TTR to determine the amount of misfolded TTR in the sample.

[0073] Some such methods further comprise comparing a signal from the reporter antibody from a calibration curve of signal versus amount of misfolded TTR to determine the amount of misfolded TTR in the sample. In some such methods, a signal from the reporter antibody is proportional to the amount of misfolded TTR in the sample.

[0074] In some such methods, the sample is from a human. In some such methods, the sample is a body fluid. In some such methods, the sample is plasma of a human.

[0075] In an embodiment, the presence of misfolded TTR is used to diagnose a subject from whom the sample was obtained with a transthyretin-mediated amyloidosis. In an embodiment, the transthyretin-mediated amyloidosis is a familial transthyretin amyloidosis or a sporadic wild-type transthyretin amyloidosis. In an embodiment, the subject has been identified as at risk of a familial transthyretin amyloidosis based on genetic testing.

[0076] In an embodiment, the subject does not show symptoms of a familial transthyretin amyloidosis. In an embodiment, the subject does not have polyneuropathy or cardiomyopathy.

[0077] In an embodiment, the familial transthyretin amyloidosis is familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA).

[0078] In an embodiment, the biological sample is from a patient receiving treatment for a transthyretin-mediated amyloidosis.

[0079] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising comparing the amount of misfolded TTR in a sample from a subject previously treated for transthyretin mediated amyloidosis with the amount of misfolded TTR detected in the subject prior to treatment or during an earlier stage of treatment; and increasing the dose or frequency of administration of the prior treatment if the amount of misfolded TTR is the same or greater than that previously detected; or decreasing the

dose or frequency of administration of the prior treatment or discontinuing the prior treatment if the amount of misfolded TTR is less than that previously detected. In an embodiment, the misfolded TTR is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0080] In some such methods, the prior treatment is by intravenous administration of an anti-TTR antibody and if the amount of misfolded TTR is less than that previously detected, the prior treatment is discontinued and replaced with treatment with a TTR stabilizer, antisense oligonucleotide based therapy, RNA interference therapy or combination therapy with doxycycline and tauroursodeoxycholic acid. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0081] In some such methods, the anti-TTR antibody is 14G8. In some such methods, the subject no longer receives treatment with the anti-TTR antibody. In some such methods, the TTR tetramer stabilizer is tafamidis or diflunisal. In some such methods, the TTR tetramer stabilizer is diflunisal. In some such methods, the antisense oligonucleotide based therapeutic is inotersen. In some such methods, the RNAi based therapeutic is patisiran or revusiran.

[0082] In another aspect, the invention provides a method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising comparing the amount of reporter antibody binding detected by the method of claim 46 in a sample from a subject before initiating treatment for transthyretin mediated amyloidosis with the amount of reporter antibody binding detected in the subject after initiating treatment; and increasing the dose or frequency of administration of the treatment if the amount of reporter antibody binding is the same or greater than that previously detected; or decreasing the dose or frequency of administration of the

treatment or discontinuing the treatment if the amount of reporter antibody binding is less than that previously detected. In an embodiment, the misfolded TTR is detected by a method comprising contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

[0083] In some methods, a transthyretin-mediated amyloidosis is distinguished from amyloid light-chain (AL) amyloidosis. In some methods, the sample is from a transgenic mouse with a transgene expressing human TTR.

[0084] In another aspect, the invention provides a method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample; the method comprising:

- (a) dividing a biological sample into two portions;
- (b) detecting total misfolded TTR in a first portion of the biological sample by
 - (i) contacting the first portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and
 - (ii) detecting the reporter antibody bound to the misfolded TTR in step (i), if any, to indicate presence or absence of the misfolded TTR;
- (d) detecting total multimeric misfolded TTR in a second portion of the biological sample by
 - (i) contacting the second portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a

reporter antibody that specifically binds to an epitope within residues 101-109 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody bound to the multimeric misfolded TTR in step (a), if any, to indicate presence or absence of the multimeric misfolded TTR.

(e) calculating a ratio of the level of total multimeric misfolded TTR of (c) to the level of total misfolded TTR of (b).

BRIEF DESCRIPTION OF THE DRAWINGS

[0085] FIG. 1 depicts the results of a sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform showing that 9D5 detects elevated misfolded TTR in plasma samples from transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant, in an assay using a polyclonal anti-TTR reporter antibody.

[0086] FIG. 2 depicts results of an ex vivo target engagement assay, using a 9D5 capture antibody and a polyclonal anti-TTR reporter antibody, showing that m14G8 reduces levels of free misfolded TTR when spiked into patient plasma.

[0087] FIG. 3 depicts the results of a sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform showing that 9D5 detects elevated misfolded TTR in plasma samples from transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant, in an assay using an 18C5 reporter antibody.

[0088] FIG. 4 depicts results of a Western blot experiment showing that 18C5 has strong reactivity toward denatured TTR monomer, minor reactivity toward denatured dimer, and very weak reactivity toward native TTR species.

[0089] FIG. 5 depicts results of a Western blot experiment showing that a commercial TTR antibody could not distinguish between native versus denatured TTR and showed very strong reactivity toward monomeric as well as dimeric native and denatured TTR

[0090] FIG. 6 depicts the results of a sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform showing that 18C5 detects elevated misfolded TTR in plasma samples from transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant.

[0091] FIG. 7 depicts the results of a sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform showing that 18C5 detects elevated multimeric misfolded TTR in plasma samples from transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant.

[0092] FIG. 8 depicts the results of a Western blot experiment showing that 9D5 detects elevated levels of mis-TTR (misfolded TTR monomers and oligomers) in plasma from hereditary ATTR patients.

[0093] FIG. 9 depicts a diagram of a pharmacodynamic assay to measure binding of a mis-TTR mAb (m14G8) to plasma mis-TTR (target engagement).

[0094] FIG. 10 depicts the results of a sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform showing that 9D5 detects elevated misfolded TTR in plasma samples from transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant, in an assay using a polyclonal anti-TTR reporter antibody.

[0095] FIG. 11 depicts an alignment of heavy chain variable regions of the mouse 18C5 antibody (SEQ ID NO: 81), human germline sequence IGHV3-48*01 (SEQ ID NO:84), human acceptor 5VZY-VH_huFrwk (Crenefab-VH) (SEQ ID NO:83), and humanized versions of the 18C5 antibody (hu18C5_VH-v1 and hu18C5_VH-v2, SEQ ID NOs: 84 and 85, respectively). CDRs defined according to Kabat/Chothia Composite are bolded in the mouse 18C5 heavy chain variable region sequence.

[0096] FIG. 12 depicts an alignment of light chain variable regions of the mouse 18C5 antibody (SEQ ID NO:87), human germline sequence IGKV2-30*02 (SEQ ID NO:90), human acceptor 5VZY-VL_huFrwk (Crenefab-VL) (SEQ ID NO:89), and humanized versions of the 18C5 antibody (hu18C5-VL-v1 and hu18C5-VL-v2, SEQ ID NOs: 91 and 92, respectively). CDRs

defined according to Kabat/Chothia Composite are bolded in the mouse 18C5 light chain variable region sequence.

BRIEF DESCRIPTION OF THE SEQUENCES

[0097] SEQ ID NO:1 sets forth the amino acid sequence of a heavy chain variable region of the mouse 18C5 antibody with signal peptide.

[0098] SEQ ID NO:2 sets forth a nucleic acid sequence encoding a heavy chain variable region of the mouse 18C5 antibody with signal peptide.

[0099] SEQ ID NO:3 sets forth the amino acid sequence of a light chain variable region of the mouse 18C5 antibody with signal peptide.

[0100] SEQ ID NO:4 sets forth a nucleic acid sequence encoding a light chain variable region of the mouse 18C5 antibody with signal peptide.

[0101] SEQ ID NO:5 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-H1 of the mouse 18C5 antibody.

[0102] SEQ ID NO:6 sets forth a nucleic acid sequence encoding a Kabat/Chothia Composite composite CDR-H1 of the mouse 18C5 antibody.

[0103] SEQ ID NO:7 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-H2 of the mouse 18C5 antibody.

[0104] SEQ ID NO:8 sets forth a nucleic acid sequence encoding a Kabat/Chothia Composite CDR-H2 of the mouse 18C5 antibody.

[0105] SEQ ID NO:9 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-H3 of the mouse 18C5 antibody.

[0106] SEQ ID NO:10 sets forth a nucleic acid sequence encoding a Kabat/Chothia Composite CDR-H3 of the mouse 18C5 antibody.

[0107] SEQ ID NO:11 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-L1 of the mouse 18C5 antibody.

[0108] SEQ ID NO:12 sets forth a nucleic acid sequence encoding a Kabat/Chothia Composite CDR-L1 of the mouse 18C5 antibody.

[0109] SEQ ID NO:13 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-L2 of the mouse 18C5 antibody.

[0110] SEQ ID NO:14 sets forth a nucleic acid sequence encoding a Kabat/Chothia Composite CDR-L2 of the mouse 18C5 antibody.

[0111] SEQ ID NO:15 sets forth the amino acid sequence of a Kabat/Chothia Composite CDR-L3 of the mouse 18C5 antibody.

[0112] SEQ ID NO:16 sets forth a nucleic acid sequence encoding the a Kabat/Chothia Composite CDR-L3 of the mouse 18C5 antibody.

[0113] SEQ ID NO:17 sets forth the amino acid sequence of a chimeric 18C5 heavy chain constant region (human IgG1).

[0114] SEQ ID NO:18 sets forth a nucleic acid sequence encoding the amino acid sequence of a chimeric 18C5 heavy chain constant region (human IgG1).

[0115] SEQ ID NO:19 sets forth the amino acid sequence of a chimeric 18C5 light chain constant region (human kappa).

[0116] SEQ ID NO:20 sets forth a nucleic acid sequence encoding the amino acid sequence of a chimeric 18C5 light chain constant region (human kappa).

[0117] SEQ ID NO:21 sets forth the amino acid sequence of an exemplary IgG1 heavy chain constant region.

[0118] SEQ ID NO:22 sets forth the amino acid sequence of an exemplary IgG1 G1m3 heavy chain constant region.

[0119] SEQ ID NO:23 sets forth the amino acid sequence of an exemplary IgG1 G1m3 heavy chain constant region.

[0120] SEQ ID NO:24 sets forth the amino acid sequence of an exemplary light chain constant region with N-terminal Arginine.

[0121] SEQ ID NO:25 sets forth the amino acid sequence of an exemplary light chain constant region without N-terminal Arginine.

[0122] SEQ ID NO:26 sets forth the amino acid sequence of human transthyretin set forth in accession number P02766.1 (UniProt).

[0123] SEQ ID NO:27 sets forth the amino acid sequence of human transthyretin set forth in accession number AAB35639.1 (GenBank).

[0124] SEQ ID NO:28 sets forth the amino acid sequence of human transthyretin set forth in accession number AAB35640.1 (GenBank).

[0125] SEQ ID NO:29 sets forth the amino acid sequence of human transthyretin set forth in accession number and ABI63351.1 (GenBank).

[0126] SEQ ID NO:30 sets forth the amino acid sequence of residues 101-109 of human transthyretin.

[0127] SEQ ID NO:31 sets forth the amino acid sequence of residues 87-127 of human transthyretin.

[0128] SEQ ID NO:32 sets forth a nucleic acid sequence encoding an exemplary IgG1 G1m3 heavy chain constant region.

[0129] SEQ ID NO:33 sets forth a nucleic acid sequence encoding an exemplary light chain constant region with C-terminal Arginine.

[0130] SEQ ID NO:34 sets forth a nucleic acid sequence encoding an exemplary light chain constant region without C-terminal Arginine.

[0131] SEQ ID NO:35 sets forth the amino acid sequence of a heavy chain constant region signal peptide.

[0132] SEQ ID NO:36 sets forth a nucleic acid sequence encoding a heavy chain constant region signal peptide.

[0133] SEQ ID NO:37 sets forth the amino acid sequence of a light chain constant region signal peptide.

[0134] SEQ ID NO:38 sets forth a nucleic acid sequence encoding a light chain constant region signal peptide.

[0135] SEQ ID NO: 39 sets forth the amino acid sequence of a Kabat CDR-H1 of antibody 14G8.

[0136] SEQ ID NO: 40 sets forth the amino acid sequence of a Kabat CDR-H2 of antibody 14G8.

[0137] SEQ ID NO: 41 sets forth the amino acid sequence of a Kabat CDR-H3 of antibody 14G8.

[0138] SEQ ID NO: 42 sets forth the amino acid sequence of a Kabat CDR-L1 of antibody 14G8.

[0139] SEQ ID NO: 43 sets forth the amino acid sequence of a Kabat CDR-L2 of antibody 14G8.

[0140] SEQ ID NO: 44 sets forth the amino acid sequence of a Kabat CDR-L3 of antibody 14G8.

[0141] SEQ ID NO: 45 sets forth the amino acid sequence of an epitope of antibody 5A1.

[0142] SEQ ID NO: 46 sets forth the amino acid sequence of a Kabat CDR-H1 of antibody 5A1.

[0143] SEQ ID NO: 47 sets forth the amino acid sequence of a Kabat CDR-H2 of antibody 5A1.

[0144] SEQ ID NO: 48 sets forth the amino acid sequence of a Kabat CDR-H3 of antibody 5A1.

- [0145] SEQ ID NO: 49 sets forth the amino acid sequence of a Kabat CDR-L1 of antibody 5A1.
- [0146] SEQ ID NO: 50 sets forth the amino acid sequence of a Kabat CDR-L2 of antibody 5A1.
- [0147] SEQ ID NO: 51 sets forth the amino acid sequence of a Kabat CDR-L3 of antibody 5A1.
- [0148] SEQ ID NO: 52 sets forth the amino acid sequence of a Kabat CDR-H1 of antibody 6C1.
- [0149] SEQ ID NO: 53 sets forth the amino acid sequence of a Kabat CDR-H2 of antibody 6C1.
- [0150] SEQ ID NO: 54 sets forth the amino acid sequence of a Kabat CDR-H3 of antibody 6C1.
- [0151] SEQ ID NO: 55 sets forth the amino acid sequence of a Kabat CDR-L1 of antibody 6C1.
- [0152] SEQ ID NO: 56 sets forth the amino acid sequence of a Kabat CDR-L2 of antibody 6C1.
- [0153] SEQ ID NO: 57 sets forth the amino acid sequence of a Kabat CDR-L3 of antibody 6C1.
- [0154] SEQ ID NO: 58 sets forth the amino acid sequence of a VH region of antibody AD7F6.
- [0155] SEQ ID NO: 59 sets forth the amino acid sequence of a VL region of antibody AD7F6.
- [0156] SEQ ID NO: 60 sets forth the amino acid sequence of a CDR-H1 of antibody RT24.
- [0157] SEQ ID NO: 61 sets forth the amino acid sequence of a CDR-H2 of antibody RT24.
- [0158] SEQ ID NO: 62 sets forth the amino acid sequence of a CDR-H3 of antibody RT24.
- [0159] SEQ ID NO: 63 sets forth the amino acid sequence of a CDR-L1 of antibody RT24.
- [0160] SEQ ID NO: 64 sets forth the amino acid sequence of a CDR-L2 of antibody RT24.
- [0161] SEQ ID NO: 65 sets forth the amino acid sequence of a CDR-L3 of antibody RT24.
- [0162] SEQ ID NO: 66 sets forth the amino acid sequence of a CDR-H1 of antibody NI-301.35G11.
- [0163] SEQ ID NO: 67 sets forth the amino acid sequence of a CDR-H2 of antibody NI-301.35G11.

[0164] SEQ ID NO: 68 sets forth the amino acid sequence of a CDR-H3 of antibody NI-301.35G11.

[0165] SEQ ID NO: 69 sets forth the amino acid sequence of a CDR-L1 of antibody NI-301.35G11.

[0166] SEQ ID NO: 70 sets forth the amino acid sequence of a CDR-L2 of antibody NI-301.35G11.

[0167] SEQ ID NO: 71 sets forth the amino acid sequence of a CDR-L3 of antibody NI-301.35G11.

[0168] SEQ ID NO: 72 sets forth the amino acid sequence of an epitope of antibodies MFD101, MFD102, MFD103, MFD105.

[0169] SEQ ID NO: 73 sets forth the amino acid sequence of an epitope of antibodies MFD107, MFD108, MFD109, MFD111.

[0170] SEQ ID NO: 74 sets forth the amino acid sequence of an epitope of antibody MFD114.

[0171] SEQ ID NO: 75 sets forth the amino acid sequence of a Kabat CDR-H1 of antibody 9D5.

[0172] SEQ ID NO: 76 sets forth the amino acid sequence of a Kabat CDR-H2 of antibody 9D5.

[0173] SEQ ID NO: 77 sets forth the amino acid sequence of a Kabat CDR-H3 of antibody 9D5.

[0174] SEQ ID NO: 78 sets forth the amino acid sequence of a Kabat CDR-L1 of antibody 9D5.

[0175] SEQ ID NO: 79 sets forth the amino acid sequence of a Kabat CDR-L2 of antibody 9D5.

[0176] SEQ ID NO: 80 sets forth the amino acid sequence of a Kabat CDR-L3 of antibody 9D5.

[0177] SEQ ID NO: 81 sets forth the amino acid sequence of a mature heavy chain variable region of the mouse 18C5 antibody.

[0178] SEQ ID NO: 82 sets forth the amino acid sequence of a heavy chain variable region of the murine anti-pyroglutamate-Abeta antibody Fab c#17, GenBank Acc. No. 1212215935.

[0179] SEQ ID NO: 83 sets forth the amino acid sequence of a heavy chain variable region of humanized Crenezumab Fab (CreneFab) PDB: 5VZY, GenBank Acc. No. 1229749875.

[0180] SEQ ID NO: 84 sets forth the amino acid sequence of a heavy chain variable region of the human germline sequence IGHV3-48*01, GenBank Acc. No. 1FN550289.1.

[0181] SEQ ID NO: 85 sets forth the amino acid sequence of a heavy chain variable region of the humanized 18C5 antibody hu18C5-VH_1.

[0182] SEQ ID NO: 86 sets forth the amino acid sequence of a heavy chain variable region of the humanized 18C5 antibody hu18C5-VH_2.

[0183] SEQ ID NO: 87 sets forth the amino acid sequence of a mature light chain variable region of the mouse 18C5 antibody.

[0184] SEQ ID NO: 88 sets forth the amino acid sequence of a light chain variable region of the murine anti-pyroglutamate-Abeta antibody Fab c#17, GenBank Acc. No. 1212215934.

[0185] SEQ ID NO: 89 sets forth the amino acid sequence of a light chain variable region of humanized Crenezumab Fab (CreneFab) PDB: 5VZY, GenBank Acc. No. 1229749876.

[0186] SEQ ID NO: 90 sets forth the amino acid sequence of a light chain variable region of the human germline sequence IGKV2-30*2, GenBank Acc. No. CAA77315.

[0187] SEQ ID NO: 91 sets forth the amino acid sequence of a light chain variable region of the humanized 18C5 antibody hu18C5-VL_1.

[0188] SEQ ID NO: 92 sets forth the amino acid sequence of a light chain variable region of the humanized 18C5 antibody hu18C5-VL_2.

[0189] SEQ ID NO: 93 sets forth the amino acid sequence of Kabat CDR-H1 of the mouse 18C5 antibody.

[0190] SEQ ID NO: 94 sets forth the amino acid sequence of Chothia CDR-H1 of the mouse 18C5 antibody.

[0191] SEQ ID NO: 95 sets forth the amino acid sequence of Contact CDR-H1 of the mouse 18C5 antibody.

[0192] SEQ ID NO: 96 sets forth the amino acid sequence of Chothia CDR-H2 of the mouse 18C5 antibody.

[0193] SEQ ID NO: 97 sets forth the amino acid sequence of AbM CDR-H2 of the mouse 18C5 antibody.

[0194] SEQ ID NO: 98 sets forth the amino acid sequence of Contact CDR-H2 of the mouse 18C5 antibody.

[0195] SEQ ID NO: 99 sets forth the amino acid sequence of Contact CDR-H3 of the mouse 18C5 antibody.

[0196] SEQ ID NO: 100 sets forth the amino acid sequence of Contact CDR-L1 of the mouse 18C5 antibody.

[0197] SEQ ID NO: 101 sets forth the amino acid sequence of Contact CDR-L2 of the mouse 18C5 antibody.

[0198] SEQ ID NO: 102 sets forth the amino acid sequence of Contact CDR-L3 of the mouse 18C5 antibody.

[0199] SEQ ID NO: 103 sets forth the amino acid sequence of a heavy chain variable region of the mouse 9D5 antibody.

[0200] SEQ ID NO: 104 sets forth the amino acid sequence of a light chain variable region of the mouse 9D5 antibody.

DEFINITIONS

[0201] Monoclonal antibodies or other biological entities are typically provided in isolated form. This means that an antibody or other biologically entity is typically at least 50% w/w pure of interfering proteins and other contaminants arising from its production or purification but does not exclude the possibility that the monoclonal antibody is combined with an excess of pharmaceutically acceptable carrier(s) or other vehicle intended to facilitate its use. Sometimes monoclonal antibodies are at least 60%, 70%, 80%, 90%, 95% or 99% w/w pure of interfering

proteins and contaminants from production or purification. Often an isolated monoclonal antibody or other biological entity is the predominant macromolecular species remaining after its purification.

[0202] Specific binding of an antibody to its target antigen means an affinity of at least 10^6 , 10^7 , 10^8 , 10^9 , or 10^{10} M^{-1} . Specific binding is detectably higher in magnitude and distinguishable from non-specific binding occurring to at least one unrelated target. Specific binding can be the result of formation of bonds between particular functional groups or particular spatial fit (*e.g.*, lock and key type) whereas nonspecific binding is usually the result of van der Waals forces. Specific binding does not however necessarily imply that an antibody binds one and only one target.

[0203] The basic antibody structural unit is a tetramer of subunits. Each tetramer includes two identical pairs of polypeptide chains, each pair having one "light" (about 25 kDa) and one "heavy" chain (about 50-70 kDa). The amino-terminal portion of each chain includes a variable region of about 100 to 110 or more amino acids primarily responsible for antigen recognition. This variable region is initially expressed linked to a cleavable signal peptide. The variable region without the signal peptide is sometimes referred to as a mature variable region. Thus, for example, a light chain mature variable region means a light chain variable region without the light chain signal peptide. The carboxy-terminal portion of each chain defines a constant region primarily responsible for effector function.

[0204] Light chains are classified as either kappa or lambda. Heavy chains are classified as gamma, mu, alpha, delta, or epsilon, and define the antibody's isotype as IgG, IgM, IgA, IgD and IgE, respectively. Within light and heavy chains, the variable and constant regions are joined by a "J" region of about 12 or more amino acids, with the heavy chain also including a "D" region of about 10 or more amino acids. *See generally, Fundamental Immunology*, Paul, W., ed., 2nd ed. Raven Press, N.Y., 1989, Ch. 7 (incorporated by reference in its entirety for all purposes).

[0205] An immunoglobulin light or heavy chain variable region (also referred to herein as a "light chain variable domain" ("VL domain") or "heavy chain variable domain" ("VH domain"), respectively) consists of a "framework" region interrupted by three "complementarity determining regions" or "CDRs." The framework regions serve to align the CDRs for specific

binding to an epitope of an antigen. The CDRs include the amino acid residues of an antibody that are primarily responsible for antigen binding. From amino-terminus to carboxyl-terminus, both VL and VH domains comprise the following framework (FR) and CDR regions: FR1, CDR1, FR2, CDR2, FR3, CDR3, and FR4. CDRs 1, 2, and 3 of a VL domain are also referred to herein, respectively, as CDR-L1, CDR-L2, and CDR-L3; CDRs 1, 2, and 3 of a VH domain are also referred to herein, respectively, as CDR-H1, CDR-H2, and CDR-H3.

[0206] The assignment of amino acids to each VL and VH domain is in accordance with any conventional definition of CDRs. Conventional definitions include, the Kabat definition (Kabat, *Sequences of Proteins of Immunological Interest* (National Institutes of Health, Bethesda, MD, 1987 and 1991), The Chothia definition (Chothia & Lesk, *J. Mol. Biol.* 196:901-917, 1987; Chothia *et al.*, *Nature* 342:878-883, 1989); a composite of Chothia Kabat CDR in which CDR-H1 is a composite of Chothia and Kabat CDRs; the AbM definition used by Oxford Molecular's antibody modelling software; and, the contact definition of Martin *et al* (bioinfo.org.uk/abs) (*see* Table 1). Kabat provides a widely used numbering convention (Kabat numbering) in which corresponding residues between different heavy chains or between different light chains are assigned the same number. When an antibody is said to comprise CDRs by a certain definition of CDRs (e.g., Kabat) that definition specifies the minimum number of CDR residues present in the antibody (*i.e.*, the Kabat CDRs). It does not exclude that other residues falling within another conventional CDR definition but outside the specified definition are also present. For example, an antibody comprising CDRs defined by Kabat includes among other possibilities, an antibody in which the CDRs contain Kabat CDR residues and no other CDR residues, and an antibody in which CDR H1 is a composite Chothia-Kabat CDR H1 and other CDRs contain Kabat CDR residues and no additional CDR residues based on other definitions.

Table 1
Conventional Definitions of CDRs Using Kabat Numbering

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

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

[0207] The term “antibody” includes intact antibodies and binding fragments thereof. Typically, fragments compete with the intact antibody from which they were derived for specific binding to the target including separate heavy chains, light chains Fab, Fab', F(ab')₂, F(ab)c, Dabs, nanobodies, and Fv. Fragments can be produced by recombinant DNA techniques, or by enzymatic or chemical separation of intact immunoglobulins. The term “antibody” also includes a bispecific antibody and/or a humanized antibody. A bispecific or bifunctional antibody is an artificial hybrid antibody having two different heavy/light chain pairs and two different binding sites (*see, e.g.,* Songsivilai and Lachmann, *Clin. Exp. Immunol.*, 79:315-321 (1990); Kostelny *et al.*, *J. Immunol.*, 148:1547-53 (1992)). In some bispecific antibodies, the two different heavy/light chain pairs include a humanized 9D5 heavy chain/light chain pair and a heavy chain/light chain pair specific for a different epitope on transthyretin than that bound by 9D5. In some bispecific antibodies, the two different heavy/light chain pairs include a humanized 18C5

heavy chain/light chain pair and a heavy chain/light chain pair specific for a different epitope on transthyretin than that bound by 18C5.

[0208] In some bispecific antibodies, one heavy chain/light chain pair is a humanized 9D5 antibody or a humanized 18C5 antibody as further disclosed below and the other heavy chain/light chain pair is from an antibody that binds to a receptor expressed on the blood brain barrier, such as an insulin receptor, an insulin-like growth factor (IGF) receptor, a leptin receptor, or a lipoprotein receptor, or a transferrin receptor (Friden *et al.*, *Proc. Natl. Acad. Sci. USA* 88:4771-4775, 1991; Friden *et al.*, *Science* 259:373-377, 1993). Such a bispecific antibody can be transferred cross the blood brain barrier by receptor-mediated transcytosis. Brain uptake of the bispecific antibody can be further enhanced by engineering the bispecific antibody to reduce its affinity to the blood brain barrier receptor. Reduced affinity for the receptor resulted in a broader distribution in the brain (*see, e.g.*, Atwal *et al.*, *Sci. Trans. Med.* 3, 84ra43, 2011; Yu *et al.*, *Sci. Trans. Med.* 3, 84ra44, 2011).

[0209] Exemplary bispecific antibodies can also be: (1) a dual-variable-domain antibody (DVD-Ig), where each light chain and heavy chain contains two variable domains in tandem through a short peptide linkage (Wu *et al.*, Generation and Characterization of a Dual Variable Domain Immunoglobulin (DVD-Ig™) Molecule, In: Antibody Engineering, Springer Berlin Heidelberg (2010)); (2) a Tandab, which is a fusion of two single chain diabodies resulting in a tetravalent bispecific antibody that has two binding sites for each of the target antigens; (3) a flexibody, which is a combination of scFvs with a diabody resulting in a multivalent molecule; (4) a so-called "dock and lock" molecule, based on the "dimerization and docking domain" in Protein Kinase A, which, when applied to Fabs, can yield a trivalent bispecific binding protein consisting of two identical Fab fragments linked to a different Fab fragment; or (5) a so-called Scorpion molecule, comprising, *e.g.*, two scFvs fused to both termini of a human Fc-region. Examples of platforms useful for preparing bispecific antibodies include BiTE (Micromet), DART (MacroGenics), Fcab and Mab2 (F-star), Fc-engineered IgG1 (Xencor) or DuoBody (based on Fab arm exchange, Genmab).

[0210] The term "epitope" refers to a site on an antigen to which an antibody binds. An epitope can be formed from contiguous amino acids or noncontiguous amino acids juxtaposed by tertiary

folding of one or more proteins. Epitopes formed from contiguous amino acids (also known as linear epitopes) are typically retained on exposure to denaturing solvents whereas epitopes formed by tertiary folding (also known as conformational epitopes) are typically lost on treatment with denaturing solvents. An epitope typically includes at least 3, and more usually, at least 5 or 8-10 amino acids in a unique spatial conformation. Methods of determining spatial conformation of epitopes include, for example, x-ray crystallography and 2-dimensional nuclear magnetic resonance. *See, e.g.*, Epitope Mapping Protocols, in *Methods in Molecular Biology*, Vol. 66, Glenn E. Morris, Ed. (1996). The epitope can be linear, such as an epitope of, for example, 2-5, 3-5, 3-9, or 5-9 contiguous amino acids from SEQ ID NO:26, including for example, two or more contiguous amino acids within residues 89-97 of the mature region of SEQ ID NO:26. The epitope can also be a conformational epitope including, for example, two or more non-contiguous segments of amino acids within residues 89-97 of the mature region of SEQ ID NO:26. If an antibody is said to bind to an epitope within amino acid residues 89-97 of transthyretin (TTR) (the mature region of SEQ ID NO:26), for example, what is meant is that the epitope is within the recited range of amino acids including those defining the outer-limits of the range. It does not necessarily mean that every amino acid within the range constitutes part of the epitope. Thus, for example, an epitope within amino acid residues 89-97 of TTR may consist of amino acids 89-97, 89-96, 90-97, 89-95, 90-96, 91-97, 89-94, 90-95, 91-96, 92-97, 89-93, 90-94, 91-95, 92-96, 93-97, 89-92, 90-93, 91-94, 92-95, 93-96, 94-97, 89-91, 90-92, 91-93, 92-94, 93-95, 94-96, 95-97 of SEQ ID NO:26, among other linear segments of SEQ ID NO:45, or in the case of conformational epitopes, non-contiguous segments of amino acids of SEQ ID NO:45. Epitopes can include E89K and E89Q substitutions, E being the wildtype residue).

The epitope can be linear, such as an epitope of, for example, 2-5, 3-5, 3-9, or 5-9 contiguous amino acids from SEQ ID NO:26, including for example, two or more contiguous amino acids within residues 101-109 of the mature region of SEQ ID NO:26. The epitope can also be a conformational epitope including, for example, two or more non-contiguous segments of amino acids within residues 101-109 of the mature region of SEQ ID NO:26. If an antibody is said to bind to an epitope within amino acid residues 101-109 of transthyretin (TTR) (the mature region of SEQ ID NO:26), for example, what is meant is that the epitope is within the recited range of amino acids including those defining the outer-limits of the range. It does not necessarily mean that every amino acid within the range constitutes part of the epitope. Thus, for example, an

epitope within amino acid residues 101-109 of TTR may consist of amino acids 101-109, 101-108, 102-109, 101-107, 102-108, 103-109, 101-106, 102-107, 103-108, 104-109, 101-105, 102-106, 103-107, 104-108, 105-109, 101-104, 102-105, 103-106, 104-107, 105-108, 106-109, 101-103, 102-104, 103-105, 104-106, 105-107, 106-108, 107-109, 101-102, 102-103, 103-104, 104-105, 105-106, 106-107, 107-108, or 108-109 of SEQ ID NO:26, among other linear segments of SEQ ID NO:30, or in the case of conformational epitopes, non-contiguous segments of amino acids of SEQ ID NO:30.

[0211] Antibodies that recognize the same or overlapping epitopes can be identified in a simple immunoassay showing the ability of one antibody to compete with the binding of another antibody to a target antigen. The epitope of an antibody can also be defined by X-ray crystallography of the antibody bound to its antigen to identify contact residues. Alternatively, two antibodies have the same epitope if all amino acid mutations in the antigen that reduce or eliminate binding of one antibody reduce or eliminate binding of the other. Two antibodies have overlapping epitopes if some amino acid mutations that reduce or eliminate binding of one antibody reduce or eliminate binding of the other.

[0212] Competition between antibodies is determined by an assay in which an antibody under test inhibits specific binding of a reference antibody to a common antigen (*see, e.g., Junghans et al., Cancer Res.* 50:1495, 1990). A test antibody competes with a reference antibody if an excess of a test antibody (*e.g., at least 2x, 5x, 10x, 20x or 100x*) inhibits binding of the reference antibody by at least 50% as measured in a competitive binding assay. Some test antibodies inhibit binding of the reference antibody by at least 75%, 90% or 99%. Antibodies identified by competition assay (competing antibodies) include antibodies binding to the same epitope as the reference antibody and antibodies binding to an adjacent epitope sufficiently proximal to the epitope bound by the reference antibody for steric hindrance to occur.

[0213] The term “native” with respect to the structure transthyretin (TTR) refers to the normal folded structure of TTR in its properly functioning state (*i.e., a TTR tetramer*). As TTR is a tetramer in its natively folded form, non-native forms of TTR include, for example, misfolded TTR tetramers, TTR monomers, aggregated forms of TTR, and fibril forms of TTR. Non-native

forms of TTR can include molecules comprising wild-type TTR amino acid sequences or mutations.

[0214] The term “misfolded” with respect to TTR refers to the secondary and tertiary structure of a TTR polypeptide monomer or multimer, and indicates that the polypeptide has adopted a conformation that is not normal for that protein in its properly functioning state. Although TTR misfolding can be caused by mutations in the protein (*e.g.*, deletion, substitution, or addition), wild-type TTR proteins can also be misfolded in diseases, exposing specific epitopes.

[0215] The term “pharmaceutically acceptable” means that the carrier, diluent, excipient, or auxiliary is compatible with the other ingredients of the formulation and not substantially deleterious to the recipient thereof.

[0216] The term “patient” includes human and other mammalian subjects that receive either prophylactic or therapeutic treatment.

[0217] An individual is at increased risk of a disease if the subject has at least one known risk-factor (*e.g.*, genetic, biochemical, family history, and situational exposure) placing individuals with that risk factor at a statistically significant greater risk of developing the disease than individuals without the risk factor.

[0218] The term “biological sample” refers to a sample of biological material within or obtainable from a biological source, for example a human or mammalian subject. Such samples can be organs, organelles, tissues, sections of tissues, bodily fluids, peripheral blood, blood plasma, blood serum, cells, molecules such as proteins and peptides, and any parts or combinations derived therefrom. The term biological sample can also encompass any material derived by processing the sample. Derived material can include cells or their progeny. Processing of the biological sample may involve one or more of filtration, distillation, extraction, concentration, fixation, inactivation of interfering components, and the like.

[0219] The term “control sample” refers to a biological sample not known or suspected to include monomeric, misfolded, aggregated, or fibril forms of transthyretin (TTR), such as in TTR amyloid deposits. Control samples can be obtained from individuals not afflicted with a TTR amyloidosis or a specifically chosen type of TTR amyloidosis. Alternatively, control

samples can be obtained from patients afflicted with TTR amyloidosis or a specifically chosen type of TTR amyloidosis. Such samples can be obtained at the same time as a biological sample thought to comprise the TTR amyloidosis or on a different occasion. A biological sample and a control sample can both be obtained from the same tissue (*e.g.*, a tissue section containing both TTR amyloid deposits and surrounding normal tissue). Preferably, control samples consist essentially or entirely of tissue free of TTR amyloid deposits and can be used in comparison to a biological sample thought to comprise TTR amyloid deposits. Preferably, the tissue in the control sample is the same type as the tissue in the biological sample (*e.g.*, cardiomyocytes in the heart).

[0220] The term “disease” refers to any abnormal condition that impairs physiological function. The term is used broadly to encompass any disorder, illness, abnormality, pathology, sickness, condition, or syndrome in which physiological function is impaired, irrespective of the nature of the etiology.

[0221] The term “symptom” refers to a subjective evidence of a disease, such as altered gait, as perceivable by a subject. A “sign” refers to objective evidence of a disease as observable by a physician.

[0222] For purposes of classifying amino acids substitutions as conservative or nonconservative, amino acids are grouped as follows: Group I (hydrophobic side chains): met, ala, val, leu, ile; Group II (neutral hydrophilic side chains): asn, gln, cys, ser, thr; Group III (acidic side chains): asp, glu; Group IV (basic side chains): his, lys, arg; Group V (residues influencing chain orientation): gly, pro; and Group VI (aromatic side chains): trp, tyr, phe. Conservative substitutions involve substitutions between amino acids in the same class. Non-conservative substitutions constitute exchanging a member of one of these classes for a member of another.

[0223] Percentage sequence identities are determined with antibody sequences maximally aligned by the Kabat numbering convention. After alignment, if a subject antibody region (*e.g.*, the entire mature variable region of a heavy or light chain) is being compared with the same region of a reference antibody, the percentage sequence identity between the subject and reference antibody regions is the number of positions occupied by the same amino acid in both

the subject and reference antibody region divided by the total number of aligned positions of the two regions, with gaps not counted, multiplied by 100 to convert to percentage.

[0224] Compositions or methods “comprising” or “including” one or more recited elements may include other elements not specifically recited. For example, a composition that “comprises” or “includes” an antibody may contain the antibody alone or in combination with other ingredients.

[0225] Designation of a range of values includes all integers within or defining the range, and all subranges defined by integers within the range.

[0226] Unless otherwise apparent from the context, the term “about” encompasses values within a standard margin of error of measurement (*e.g.*, SEM) of a stated value.

[0227] Statistical significance means $p \leq 0.05$.

[0228] Antibodies of the invention can be administered concomitant with another treatment for the same indication as the antibody, meaning that the other treatment is administered at least once during the period in which the antibody is administered, such period beginning one month before the first dosing and ending one month after the last dosing of the antibody. The other treatment can be administered at recurring intervals during this period, which may or may not be the same as the intervals at which the antibody is administered. The other treatment may be a symptomatic treatment.

[0229] A treatment is symptomatic if it only affects one or more symptoms of a disease, not its cause, *i.e.*, its etiology.

[0230] The singular forms of the articles “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise. For example, the term “a compound” or “at least one compound” can include a plurality of compounds, including mixtures thereof.

DETAILED DESCRIPTION

I. General

[0231] The invention provides antibodies that specifically bind to residues 89-97 or to residues 101-109 of transthyretin (TTR). Some antibodies bind any or all of monomeric, misfolded, aggregated, or fibril forms of TTR preferentially relative to native tetrameric form of TTR. Some antibodies bind either or both of monomeric or misfolded forms of TTR preferentially relative to native tetrameric form of TTR. The antibodies can be used for treating or effecting prophylaxis of diseases or disorders associated with TTR accumulation or accumulation of TTR deposits (*e.g.*, TTR amyloidosis). The antibodies can also be used for diagnosing TTR amyloidosis and inhibiting or reducing aggregation of TTR. The antibodies can also be used to demonstrate pharmacodynamics effects of a transthyretin-mediated amyloidosis therapy, among other applications. Preferential binding means an association constant at least five times higher for any or all of monomeric, misfolded, aggregated, or fibril forms of TTR than for native tetrameric form of TTR. Optionally, the association constant is at least ten times higher for any or all of monomeric, misfolded, aggregated, or fibril forms of TTR than for native tetrameric form of TTR. Optionally, the antibody, such as 9D5 or 18C5, for example, lacks specific binding to native tetrameric form of TTR.

II. Target Molecules

[0232] Transthyretin (TTR) is a 127-amino acid, 55 kDa serum and cerebrospinal fluid transport protein primarily synthesized by the liver. It has also been referred to as prealbumin, thyroxine binding prealbumin, ATTR, and TBPA. In its native state, TTR exists as a tetramer. In homozygotes, the tetramers comprise identical 127-amino-acid beta-sheet-rich subunits. In heterozygotes, the TTR tetramers are made up of variant and/or wild-type subunits, typically combined in a statistical fashion.

[0233] The established function of TTR in the blood is to transport *holo*-retinol binding protein. Although TTR is the major carrier of thyroxine (T₄) in the blood of rodents, utilizing binding sites that are orthogonal to those used for *holo*-retinol binding protein, the T₄ binding sites are effectively unoccupied in humans.

[0234] TTR is one of at least thirty different human proteins whose extracellular misfolding and/or misassembly (amyloidogenesis) into a spectrum of aggregate structures is thought to cause degenerative diseases referred to as amyloid diseases. TTR undergoes conformational changes in order to become amyloidogenic. Dissociation of the TTR tetramer and partial unfolding exposes stretches of largely uncharged hydrophobic residues in an extended conformation that efficiently misassemble into largely unstructured spherical aggregates that ultimately undergo conformation conversion into cross-beta sheet amyloid structures.

[0235] Unless otherwise apparent from context, reference to transthyretin (TTR) or its fragments or domains includes the natural human amino acid sequences including isoforms, mutants (e.g., E89K and E89Q), and allelic variants thereof. Exemplary TTR polypeptide sequences are designated by Accession Numbers P02766.1 (UniProt) (SEQ ID NO:26), AAB35639.1 (GenBank) (SEQ ID NO:27), AAB35640.1 (GenBank) (SEQ ID NO:28), and ABI63351.1 (GenBank) (SEQ ID NO:29). Residues are numbered according to Swiss Prot P02766.1, with the first amino acid of the mature protein (*i.e.*, not including the 20 amino acid signal sequence) designated residue 1. In any other TTR protein, residues are numbered according to the corresponding residues in P02766.1 on maximum alignment.

III. Transthyretin Amyloidosis

[0236] Transthyretin (TTR) amyloidosis is a systemic disorder characterized by pathogenic, misfolded TTR and the extracellular deposition of amyloid fibrils composed of TTR. TTR amyloidosis is generally caused by destabilization of the native TTR tetramer form (due to environmental or genetic conditions), leading to dissociation, misfolding, and aggregation of TTR into amyloid fibrils that accumulate in various organs and tissues, causing progressive dysfunction. *See, e.g.*, Almeida and Saraiva, *FEBS Letters* 586:2891-2896 (2012); Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013).

[0237] In humans, both wild-type TTR tetramers and mixed tetramers comprised of mutant and wild-type subunits can dissociate, misfold, and aggregate, with the process of amyloidogenesis leading to the degeneration of affected tissue. Thus, TTR amyloidoses encompass diseases caused by pathogenic misfolded TTR resulting from mutations in TTR or resulting from non-mutated, misfolded TTR.

[0238] For example, wild-type ATTR amyloidosis (also called senile systemic amyloidosis or SSA) and senile cardiac amyloidosis (SCA) are age-related types of amyloidosis that result from the deposition of wild-type TTR amyloid outside and within the cardiomyocytes of the heart. TTR amyloidosis is also the most common form of hereditary (familial) amyloidosis, which is caused by mutations that destabilize the TTR protein. The TTR amyloidoses associated with point mutations in the TTR gene include familial amyloid polyneuropathy (FAP), familial amyloid cardiomyopathy (FAC), and the rare central nervous system selective amyloidosis (CNSA). Patients with hereditary (familial) TTR amyloidosis are almost always heterozygotes, meaning that the TTR tetramers are composed of mutant and/or wild-type TTR subunits, generally statistically distributed. Hereditary (familial) versions of TTR amyloidosis are generally autosomal dominant and are typically earlier onset than the sporadic diseases (SSA and SCA).

[0239] There are over 100 mutations in the gene encoding TTR that have been implicated in the autosomal dominant disorders FAP and FAC. *See, e.g.,* US 2014/0056904; Saraiva, *Hum. Mutat.* 17(6):493-503 (2001); Damas and Saraiva, *J. Struct. Biol.* 130:290-299; Dwulet and Benson, *Biochem. Biophys. Res. Commun.* 114:657-662 (1983). These amyloid-causing mutations are distributed throughout the entire molecule of TTR. Generally, the more destabilizing the mutant subunits are to the TTR tetramer structure, the earlier the onset of amyloid disease. The pathogenic potential of a TTR variant is generally determined by a combination of its instability and its cellular secretion efficiency. The initial pathology caused by some TTR variants comes from their selective destruction of cardiac tissue, whereas that from other TTR variants comes from compromising the peripheral and autonomic nervous system. The tissue damage caused by TTR amyloidogenesis appear to stem largely from the toxicity of small, diffusible TTR aggregates, although accumulation of extracellular amyloid may contribute and almost certainly compromises organ structure in the late stages of the TTR amyloidosis. Exemplary TTR mutations include V30M, Y114C, G47R, S50I, E61L, T49S, F33V, A45T, E89K, E89Q, and V122I.

[0240] TTR amyloidosis presents in many different forms, with considerable phenotypic variation across individuals and geographic locations. For example, TTR amyloidosis can

present as a progressive, axonal sensory autonomic and motor neuropathy. TTR amyloidosis can also present as an infiltrative cardiomyopathy.

[0241] The age at onset of disease-related symptoms varies between the second and ninth decades of life, with great variations across different populations. The multisystem involvement of TTR amyloidosis is a clue to its diagnosis. For example, TTR amyloidosis diagnosis is considered when one or several of the following are present: (1) family history of neuropathic disease, especially associated with heart failure; (2) neuropathic pain or progressive sensory disturbances of unknown etiology; (3) carpal tunnel syndrome without obvious cause, particularly if it is bilateral and requires surgical release; (4) gastrointestinal motility disturbances or autonomic nerve dysfunction of unknown etiology (*e.g.*, erectile dysfunction, orthostatic hypotension, neurogenic bladder); (5) cardiac disease characterized by thickened ventricular walls in the absence of hypertension; (6) advanced atrio-ventricular block of unknown origin, particularly when accompanied by a thickened heart; and (6) vitreous body inclusions of the cotton-wool type. See Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013). Other symptoms can include, for example, polyneuropathy, sensory loss, pain, weakness in lower limbs, dyshidrosis, diarrhea, constipation, weight loss, and urinary incontinence/retention.

[0242] Diagnosis of TTR amyloidosis typically relies on target organ biopsies, followed by histological staining of the excised tissue with the amyloid-specific dye, Congo red. If a positive test for amyloid is observed, immunohistochemical staining and mass spectroscopic identification of TTR is subsequently performed to ensure that the precursor protein responsible for amyloid formation is indeed TTR. Antibodies disclosed herein are useful in distinguishing TTR amyloidosis from a non-TTR amyloidosis *e.g.* amyloid light-chain (AL) amyloidosis, also known as primary systemic amyloidosis. For familial forms of the diseases, demonstration of a mutation in the gene encoding TTR is then needed before diagnosis can be made. This can be accomplished, for example, through isoelectric focusing electrophoresis, polymerase chain reaction, or laser dissection/liquid chromatography-tandem mass spectrometry. See, *e.g.*, US 2014/0056904; Ruberg and Berk, *Circulation* 126:1286-1300 (2012); Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013).

IV. Antibodies

A. *Binding Specificity and Functional Properties*

[0243] The invention provides monoclonal antibodies binding to transthyretin (TTR) protein, more specifically, to epitopes within amino acid residues 89-97 (SEQ ID NO:45) or to epitopes within amino acid residues 101-109 (SEQ ID NO:30) of TTR. Such epitopes are buried in the native TTR tetramer and exposed in monomeric, misfolded, aggregated, or fibril forms of TTR.

[0244] Such antibodies include 9D5, 18C5, and their chimeric, veneered and humanized forms. 9D5 specifically binds within amino acid residues 89-97 (SEQ ID NO:45) of TTR. 18C5 specifically binds within amino acid residues 101-109 (SEQ ID NO: 30) of TTR. These antibodies are further characterized by their ability to bind to monomeric, misfolded, aggregated, or fibril forms of TTR but not to native tetrameric form of TTR. Ability to bind to specific proteins or fragments thereof may be demonstrated using exemplary assay formats provided in the examples. Unless otherwise apparent from the context, reference to 9D5 or 18C5 should be understood as referring to any of the mouse, chimeric, veneered or humanized forms. A hybridoma cell line that produces monoclonal antibody 9D5 was deposited with the Patent Depository of the American Type Culture Collection (ATCC), Manassas, Virginia, 20110-2209 on April 4, 2017 and assigned Patent Deposit No. PTA-124078. A hybridoma cell line that produces monoclonal antibody 18C5 was deposited with the Patent Depository of the American Type Culture Collection (ATCC), Manassas, Virginia, 20110-2209 on ____ October 31, 2017 _____ and assigned Patent Deposit No. _ PTA-124570 _____.

[0245] Some antibodies bind to the same or overlapping epitope as an antibody designated 9D5. The sequences of the heavy and light chain mature variable regions of 9D5 are designated SEQ ID NOs: 81 and 82, respectively. Other antibodies having such a binding specificity can be produced by immunizing mice with TTR, or a portion thereof including the desired epitope (e.g., SEQ ID NO:45), and screening resulting antibodies for binding to monomeric TTR or a peptide comprising SEQ ID NO:45, optionally in competition with an antibody having the variable regions of mouse 18C5 (IgG1,kappa). Fragments of TTR including the desired epitope can be linked to a carrier that helps elicit an antibody response to the fragment and/or be combined with an adjuvant that helps elicit such a response. Such antibodies can be screened for differential

binding to wild-type, monomeric versions of TTR or a fragment thereof (*e.g.*, SEQ ID NO:26) compared with mutants of specified residues.

Some antibodies bind to the same or overlapping epitope as an antibody designated 18C5. The sequences of the heavy and light chain mature variable regions of 18C5 are designated SEQ ID NOs: 1 and 3, respectively. Other antibodies having such a binding specificity can be produced by immunizing mice with TTR, or a portion thereof including the desired epitope (*e.g.*, SEQ ID NO:30), and screening resulting antibodies for binding to monomeric TTR or a peptide comprising SEQ ID NO:30, optionally in competition with an antibody having the variable regions of mouse 18C5 (IgG1, kappa). Fragments of TTR including the desired epitope can be linked to a carrier that helps elicit an antibody response to the fragment and/or be combined with an adjuvant that helps elicit such a response. Such antibodies can be screened for differential binding to wild-type, monomeric versions of TTR or a fragment thereof (*e.g.*, SEQ ID NO:26) compared with mutants of specified residues.

Screening against such mutants more precisely defines the binding specificity to allow identification of antibodies whose binding is inhibited by mutagenesis of particular residues and which are likely to share the functional properties of other exemplified antibodies. The mutations can be systematic replacement substitution with alanine (or serine or glycine if an alanine is present already) one residue at a time, or more broadly spaced intervals, throughout the target or throughout a section thereof in which an epitope is known to reside. If the same set of mutations significantly reduces the binding of two antibodies, the two antibodies bind the same epitope.

[0246] Antibodies having the binding specificity of a selected murine antibody (*e.g.*, 9D5 or 18C5) can also be produced using a variant of the phage display method. *See* Winter, WO 92/20791. This method is particularly suitable for producing human antibodies. In this method, either the heavy or light chain variable region of the selected murine antibody is used as a starting material. If, for example, a light chain variable region is selected as the starting material, a phage library is constructed in which members display the same light chain variable region (*i.e.*, the murine starting material) and a different heavy chain variable region. The heavy chain variable regions can for example be obtained from a library of rearranged human heavy chain

variable regions. A phage showing strong specific binding (*e.g.*, at least 10^8 and preferably at least 10^9 M^{-1}) for monomeric TTR or a fragment thereof (*e.g.*, amino acid residues 89-97 or amino acid residues 101-109) is selected. The heavy chain variable region from this phage then serves as a starting material for constructing a further phage library. In this library, each phage displays the same heavy chain variable region (*i.e.*, the region identified from the first display library) and a different light chain variable region. The light chain variable regions can be obtained for example from a library of rearranged human variable light chain regions. Again, phage showing strong specific binding for monomeric TTR or a fragment thereof (*e.g.*, amino acid residues 89-97 or amino acid residues 101-109) are selected. The resulting antibodies usually have the same or similar epitope specificity as the murine starting material.

[0247] Other antibodies can be obtained by mutagenesis of cDNA encoding the heavy and light chains of an exemplary antibody, such as 9D5 or 18C5. Monoclonal antibodies that are at least 70%, 80%, 90%, 95%, 96%, 97%, 98%, or 99% identical to 9D5 or 18C5 in amino acid sequence of the mature heavy and/or light chain variable regions and maintain its functional properties, and/or which differ from the respective antibody by a small number of functionally inconsequential amino acid substitutions (*e.g.*, conservative substitutions), deletions, or insertions are also included in the invention. Monoclonal antibodies having at least one or all six CDR(s) as defined by conventional definition, but preferably Kabat, that are 90%, 95%, 99% or 100% identical to corresponding CDRs of 9D5 or 18C5 are also included.

[0248] The invention also provides antibodies having some or all (*e.g.*, 3, 4, 5, and 6) CDRs entirely or substantially from 9D5 or 18C5. Such antibodies can include a heavy chain variable region that has at least two, and usually all three, CDRs entirely or substantially from the heavy chain variable region of 9D5 or 18C5 and/or a light chain variable region having at least two, and usually all three, CDRs entirely or substantially from the light chain variable region of 9D5 or 18C5. The antibodies can include both heavy and light chains. A CDR is substantially from a corresponding 9D5 or 18C5 CDR when it contains no more than 4, 3, 2, or 1 substitutions, insertions, or deletions, except that CDR-H2 (when defined by Kabat) can have no more than 6, 5, 4, 3, 2, or 1 substitutions, insertions, or deletions. Such antibodies can have at least 70%, 80%, 90%, 95%, 96%, 97%, 98%, or 99% identity to 9D5 or 18C5 in the amino acid sequence of the mature heavy and/or light chain variable regions and maintain their functional properties,

and/or differ from 9D5 or 18C5 by a small number of functionally inconsequential amino acid substitutions (*e.g.*, conservative substitutions), deletions, or insertions.

[0249] Kabat CDRs (CDR-H1, CDR-H2, CDR-H3) of the heavy chain of 9D5 are designated SEQ ID NOs: 75, 76, and 77, respectively, and Kabat CDRs (CDR-L1, CDR-L2, CDR-L3) of the light chain of 9D5 are designated SEQ ID NOs: 78, 79, and 80, respectively.

[0250] Kabat/Chothia Composite CDRs (CDR-H1, CDR-H2, CDR-H3) of the heavy chain of 18C5 are designated SEQ ID NOs: 5, 7, and 9, respectively, and Kabat/Chothia Composite CDRs (CDR-L1, CDR-L2, CDR-L3) of the light chain of 18C5 are designated SEQ ID NOs: 11, 13, and 15, respectively.

[0251] Table 2 indicates the 18C5 CDRs as defined by Kabat, Chothia, Composite of Chothia and Kabat (also referred to herein as “Kabat/Chothia Composite”), AbM, and Contact.

Table 2

18C5 CDRs as defined by Kabat, Chothia, Composite of Chothia and Kabat, AbM, and Contact, Using Kabat Numbering

Loop	Kabat	Chothia	Composite of Chothia & Kabat	AbM	Contact
L1	L24--L34 SEQ ID NO:11	L24--L34 SEQ ID NO:11	L24--L34 SEQ ID NO:11	L24--L34 SEQ ID NO:11	L30--L36 SEQ ID NO: 100
L2	L50--L56 SEQ ID NO:13	L50--L56 SEQ ID NO: 13	L50--L56 SEQ ID NO: 13	L50--L56 SEQ ID NO: 13	L46--L55 SEQ ID NO: 101
L3	L89--L97 SEQ ID NO: 15	L89--L97 SEQ ID NO:15	L89--L97 SEQ ID NO: 15	L89--L97 SEQ ID NO: 15	L89--L96 SEQ ID NO: 102
H1	H31--H35B SEQ ID NO: 93	H26--H32 SEQ ID NO: 94	H26--H35B SEQ ID NO:5	H26--H35B SEQ ID NO:5	H30--H35B SEQ ID NO: 95
H2	H50--H65 SEQ ID NO: 7	H52--H56 SEQ ID NO: 96	H50--H65 SEQ ID NO: 7	H50--H58 SEQ ID NO: 97	H47--H58 SEQ ID NO: 98
H3	H95--H102 SEQ ID NO:9	H95--H102 SEQ ID NO:9	H95--H102 SEQ ID NO: 9	H95--H102 SEQ ID NO: 9	H93--H101 SEQ ID NO: 99

[0252] Some antibodies identified by such assays can bind to monomeric, misfolded, aggregated, or fibril forms of TTR but not to native tetrameric form of TTR, as described in the examples or otherwise. Likewise, some antibodies are immunoreactive on TTR-mediated amyloidosis tissue but not on healthy tissue.

[0253] Some antibodies can inhibit or reduce aggregation of TTR, inhibit or reduce TTR fibril formation, reduce or clear TTR deposits or aggregated TTR, or stabilize non-toxic conformations of TTR in an animal model or clinical trial. Some antibodies can treat, effect prophylaxis of, or delay the onset of a TTR amyloidosis as shown in an animal model or clinical trial. Exemplary animal models for testing activity against a TTR amyloidosis include those described in Kohno *et al.*, *Am. J. Path.* 150(4):1497-1508 (1997); Teng *et al.*, *Laboratory Investigations* 81:385-396 (2001); Wakasugi *et al.*, *Proc. Japan Acad.* 63B:344-347 (1987); Shimada *et al.*, *Mol. Biol. Med.* 6:333-343 (1989); Nagata *et al.*, *J. Biochem.* 117:169-175 (1995); Sousa *et al.*, *Am. J. Path.* 161:1935-1948 (2002); and Santos *et al.*, *Neurobiology of Aging* 31:280-289 (2010).

[0254] Anti-TTR antibodies including chimeric and humanized versions thereof, are useful in combination therapies, in bispecific antibodies, in methods of diagnosis and/or treatment of TTR associated disorders, and in methods of detecting TTR. Such anti-TTR antibodies, may include antibodies as in Table 3 below.

Table 3
Anti-TTR antibodies.

Name	Epitope on TTR as reported	VH/VL or CDRs as reported	Reference
9D5	EHAEEVFTA (89-97) (SEQ ID NO:45)	Kabat CDRs: CDR-H1 SEQ ID NO:75 CDR-H2 SEQ ID NO:76 CDR-H3 SEQ ID NO:77 CDR-L1 SEQ ID NO:78 CDR-L2 SEQ ID NO:79 CDR-L3 SEQ ID NO:80	WO 2016/120810 A1 ATCC Deposit No.PTA-124078 Date: April 4, 2017
14G8	EHAEEVFTA (89-97) (SEQ ID NO:45)	Kabat CDRs	WO 2016/120810 A1 ATCC Deposit No.

Name	Epitope on TTR as reported	VH/VL or CDRs as reported	Reference
		CDR-H1 SEQ ID NO:39 CDR-H2 SEQ ID NO:40 CDR-H3 SEQ ID NO:41 CDR-L1 SEQ ID NO:42 CDR-L2 SEQ ID NO:43 CDR-L3 SEQ ID NO:44	PTA-124079 Date: April 4, 2017
5A1	EHAEEVFTA (89-97) (SEQ ID NO:45)	Kabat CDRs CDR-H1 SEQ ID NO:46 CDR-H2 SEQ ID NO:47 CDR-H3 SEQ ID NO:48 CDR-L1 SEQ ID NO 49 CDR-L2 SEQ ID NO :50 CDR-L3 SEQ ID NO: 51	WO 2016/120811 ATCC Deposit No. PTA-124080 Date: April 4, 2017
6C1	EHAEEVFTA (89-97) (SEQ ID NO:45)	Kabat CDRs CDR-H1 SEQ ID NO:52 CDR-H2 SEQ ID NO:53 CDR-H3 SEQ ID NO: 54 CDR-L1 SEQ ID NO: 55 CDR-L2 SEQ ID NO:56 CDR-L3 SEQ ID NO: 57	WO 2016/120809 ATCC Deposit No. PTA-124077 Date: April 4, 2017
18C5	GPRRYTIAA (101-109) (SEQ ID NO:30)	Kabat/Chothia Composite CDRs: CDR-H1 SEQ ID NO:5 CDR-H2 SEQ ID NO: 7 CDR-H3 SEQ ID NO: 9 CDR-L1 SEQ ID NO: 11 CDR-L2 SEQ ID NO: 13	US Provisional Appl. 62/596,438, filed October 6, 2017

Name	Epitope on TTR as reported	VH/VL or CDRs as reported	Reference
		CDR-L3 SEQ ID NO: 15	
AD7F6		VH SEQ ID NO: 58 VL SEQ ID NO: 59	WO 2010/030203 A1
RT24	118-122, 115-124	CDR-H1 SEQ ID NO:60 CDR-H2 SEQ ID NO:61 CDR-H3 SEQ ID NO: 62 CDR-L1 SEQ ID NO: 63 CDR-L2 SEQ ID NO: 64 CDR-L3 SEQ ID NO: 65	WO 2015/115331
NI-301.35G11	53-63, 54-61	CDR-H1 SEQ ID NO: 66 CDR-H2 SEQ ID NO: 67 CDR-H3 SEQ ID NO:68 CDR-L1 SEQ ID NO: 69 CDR-L2 SEQ ID NO: 70 CDR-L3 SEQ ID NO:71	US 2016/0355576 A1 (
MFD101, MDF102, MFD103, MFD105	ADDTWEPFASGKT (residues 36-49) (SEQ ID NO:72)		US 2016/0039916 A1
MFD107, MFD108, MFD109, MFD111	TSESGELHGLTTE (residues 49-61) (SEQ ID NO:73)		US 2016/0039916 A1
MFD114	ALLSPYSYSTTAV (residues 109-121) (SEQ ID NO:74)		US 2016/0039916 A1
	30-66		US 2016/0039916 A1
	70-127		US 2016/0039916 A1
	80-127		US 2016/0039916 A1
	90-127		US 2016/0039916 A1

Name	Epitope on TTR as reported	VH/VL or CDRs as reported	Reference
	100-127		US 2016/0039916 A1
	110-127		US 2016/0039916 A1
	115-127		US 2016/0039916 A1

B. Non-Human Antibodies

[0255] The production of other non-human antibodies, *e.g.*, murine, guinea pig, primate, rabbit or rat, against monomeric TTR or a fragment thereof (*e.g.*, amino acid residues 89-97 or amino acid residues 101-109) can be accomplished by, for example, immunizing the animal with TTR or a fragment thereof. *See* Harlow & Lane, *Antibodies, A Laboratory Manual* (CSHP NY, 1988) (incorporated by reference for all purposes). Such an immunogen can be obtained from a natural source, by peptide synthesis, or by recombinant expression. Optionally, the immunogen can be administered fused or otherwise complexed with a carrier protein. Optionally, the immunogen can be administered with an adjuvant. Several types of adjuvant can be used as described below. Complete Freund's adjuvant followed by incomplete adjuvant is preferred for immunization of laboratory animals. Rabbits or guinea pigs are typically used for making polyclonal antibodies. Mice are typically used for making monoclonal antibodies. Antibodies are screened for specific binding to monomeric TTR or an epitope within TTR (*e.g.*, an epitope comprising one or more of amino acid residues 89-97 or of amino acid residues 101-109). Such screening can be accomplished by determining binding of an antibody to a collection of monomeric TTR variants, such as TTR variants containing amino acid residues 89-97 amino acid residues 101-109 or mutations within these residues, and determining which TTR variants bind to the antibody. Binding can be assessed, for example, by Western blot, FACS or ELISA.

C. Humanized Antibodies

[0256] A humanized antibody is a genetically engineered antibody in which CDRs from a non-human "donor" antibody are grafted into human "acceptor" antibody sequences (*see, e.g.*, Queen, US 5,530,101 and 5,585,089; Winter, US 5,225,539; Carter, US 6,407,213; Adair, US 5,859,205; and Foote, US 6,881,557). The acceptor antibody sequences can be, for example, a mature human antibody sequence, a composite of such sequences, a consensus sequence of

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

herein is not intended to be limited to the 2014 WHO INN definition of humanized antibodies. Some of the humanized antibodies provided herein have at least 85% sequence identity to human germline sequences in either or both mature variable regions and some of the humanized antibodies provided herein have less than 85% sequence identity to human germline sequences in either or both mature variable regions. Some of the mature heavy chain variable regions of the humanized antibodies provided herein have from about 60% to 100% sequence identity to human germ line sequences, such as, for example, in the range of about 60% to 69%, 70% to 79%, 80% to 84%, or 85% to 89%. Some of the mature heavy chain variable regions heavy chains fall below the 2014 WHO INN definition and have, for example, about 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, or 82%, 83%, or 84% sequence identity to human germ line sequences, while other mature heavy chain variable regions meet the 2014 WHO INN definition and have about 85%, 86%, 87%, 88%, 89% or greater sequence identity to human germ line sequences. Some of the mature light chain variable regions of the humanized antibodies provided herein have from about 60% to 100% sequence identity to human germ line sequences, such as, for example, in the range of about 80% to 84% or 85% to 89%. Some of the mature light chain variable regions fall below the 2014 WHO INN definition and have, for example, about 81%, 82%, 83% or 84% sequence identity to human germ line sequences, while other mature light chain variable regions meet the 2014 WHO INN definition and have about 85%, 86%, 87%, 88%, 89% or greater sequence identity to human germ line sequences. Some humanized antibodies provided herein that are "chimeric" under the 2014 WHO INN definition have mature heavy chain variable regions with less than 85% identity to human germ line sequences paired with mature light chain variable regions having less than 85% identity to human germ line sequences. Some humanized antibodies provided herein are "mixed" under the 2014 WHO INN definition, for example, having a mature heavy chain variable region with at least 85% sequence identity to human germ line sequences paired with a mature light chain variable region having less than 85% sequence identity to human germ line sequences, or vice versa. Some humanized antibodies provided herein meet the 2014 WHO INN definition of "humanized" and have a mature heavy chain variable region with at least 85% sequence identity to human germ line sequences paired with a mature light chain variable region having at least 85% sequence identity to human germ line sequences. Exemplary 18C5 antibodies that meet the 2014 WHO INN definition of "humanized" include antibodies having a

mature heavy chain variable region with an amino acid sequence of SEQ ID NO:85 or SEQ ID NO: 86 paired with a mature light chain variable region having an amino acid sequence of SEQ ID NO:91 or SEQ ID NO:92.

[0257] Although humanized antibodies often incorporate all six CDRs (preferably as defined by Kabat) from a mouse antibody, they can also be made with less than all CDRs (*e.g.*, at least 3, 4, or 5 CDRs) from a mouse antibody (*e.g.*, Pascalis *et al.*, *J. Immunol.* 169:3076, 2002; Vajdos *et al.*, *J. of Mol. Biol.*, 320: 415-428, 2002; Iwahashi *et al.*, *Mol. Immunol.* 36:1079-1091, 1999; Tamura *et al.*, *J. Immunol.*, 164:1432-1441, 2000).

[0258] In some antibodies only part of the CDRs, namely the subset of CDR residues required for binding, termed the SDRs, are needed to retain binding in a humanized antibody. CDR residues not contacting antigen and not in the SDRs can be identified based on previous studies (for example residues H60-H65 in CDR H2 are often not required), from regions of Kabat CDRs lying outside Chothia hypervariable loops (Chothia, *J. Mol. Biol.* 196:901, 1987), by molecular modeling and/or empirically, or as described in Gonzales *et al.*, *Mol. Immunol.* 41: 863, 2004. In such humanized antibodies at positions in which one or more donor CDR residues is absent or in which an entire donor CDR is omitted, the amino acid occupying the position can be an amino acid occupying the corresponding position (by Kabat numbering) in the acceptor antibody sequence. The number of such substitutions of acceptor for donor amino acids in the CDRs to include reflects a balance of competing considerations. Such substitutions are potentially advantageous in decreasing the number of mouse amino acids in a humanized antibody and consequently decreasing potential immunogenicity. However, substitutions can also cause changes of affinity, and significant reductions in affinity are preferably avoided. Positions for substitution within CDRs and amino acids to substitute can also be selected empirically.

[0259] The human acceptor antibody sequences can optionally be selected from among the many known human antibody sequences to provide a high degree of sequence identity (*e.g.*, 65-85% identity) between a human acceptor sequence variable region frameworks and corresponding variable region frameworks of a donor antibody chain.

[0260] An example of an acceptor sequence for the 18C5 heavy chain is the humanized Crenezumab Fab (CreneFab) VH, with PDB accession code 5VZY (SEQ ID NO:83). An example of an acceptor sequence for the 18C5 light chain is the humanized Crenezumab Fab (CreneFab) VL, with PDB accession code 5VZY (SEQ ID NO:89). Another example of an acceptor sequence for the 18C5 light chain is the human germline gene IGKV2-30*02 (SEQ ID NO:90).

[0261] If more than one human acceptor antibody sequence is selected for a chain (either light or heavy), a composite or hybrid of those acceptors can be used for that chain, and the amino acids used at different can be taken from any of the human acceptor antibody sequences used.

[0262] Certain amino acids from the human variable region framework residues can be selected for substitution based on their possible influence on CDR conformation and/or binding to antigen. Investigation of such possible influences is by modeling, examination of the characteristics of the amino acids at particular locations, or empirical observation of the effects of substitution or mutagenesis of particular amino acids.

[0263] For example, when an amino acid differs between a murine variable region framework residue and a selected human variable region framework residue, the human framework amino acid can be substituted by the equivalent framework amino acid from the mouse antibody when it is reasonably expected that the amino acid:

- (1) noncovalently binds antigen directly;
- (2) is adjacent to a CDR region or within a CDR as defined by Chothia but not Kabat;
- (3) otherwise interacts with a CDR region (*e.g.*, is within about 6 Å of a CDR region), (*e.g.*, identified by modeling the light or heavy chain on the solved structure of a homologous known immunoglobulin chain); or
- (4) is a residue participating in the VL-VH interface.

[0264] The invention provides humanized forms of the murine 18C5 antibody including 2 exemplified humanized heavy chain mature variable regions (hu18C5-VH_v1 (SEQ ID NO:85), and hu18C5-VH_v2 (SEQ ID NO:86)), and 2 exemplified humanized light chain mature variable regions (hu18C5-VL_v1 (SEQ ID NO:91) and hu18C5-VL_v2 (SEQ ID NO:92)).

[0265] In an embodiment, humanized sequences are generated using a two-stage PCR protocol that allows introduction of multiple mutations, deletions, and insertions using QuikChange site-directed mutagenesis [Wang, W. and Malcolm, B.A. (1999) *BioTechniques* 26:680-682)].

[0266] Framework residues from classes (1) through (3) as defined by Queen, US 5,530,101, are sometimes alternately referred to as canonical and vernier residues. Framework residues that help define the conformation of a CDR loop are sometimes referred to as canonical residues (Chothia & Lesk, *J. Mol. Biol.* 196:901-917 (1987); Thornton & Martin, *J. Mol. Biol.* 263:800-815 (1996)). Framework residues that support antigen-binding loop conformations and play a role in fine-tuning the fit of an antibody to antigen are sometimes referred to as vernier residues (Foote & Winter, *J. Mol. Biol.* 224:487-499 (1992)).

[0267] Other framework residues that are candidates for substitution are residues creating a potential glycosylation site. Still other candidates for substitution are acceptor human framework amino acids that are unusual for a human immunoglobulin at that position. These amino acids can be substituted with amino acids from the equivalent position of the mouse donor antibody or from the equivalent positions of more typical human immunoglobulins.

[0268] Other framework residues that are candidates for substitution are N-terminal glutamic acid residues (E) that may be replaced with glutamine (Q).

[0269] Exemplary humanized antibodies are humanized forms of the mouse 18C5, designated Hu18C5.

[0270] The mouse antibody 18C5 comprises mature heavy and light chain variable regions having amino acid sequences comprising SEQ ID NO: 81 and SEQ ID NO:87, respectively. The invention provides 2 exemplified humanized mature heavy chain variable regions: hu18C5-VH_v1 and hu18C5-VH_v2. The invention further provides 2 exemplified human mature light chain variable regions: hu18C5-VL_v1 and hu18C5-VL_v2. Alignments of the murine 18C5 and various humanized antibodies are shown for the light chain variable regions (Table 8 and Figure 12), and heavy chain variable regions (Table 9 and Figure 11).

[0271] For reasons such as possible influence on CDR conformation and/or binding to antigen, mediating interaction between heavy and light chains, interaction with the constant region, being a site for desired or undesired post-translational modification, being an unusual residue for its position in a human variable region sequence and therefore potentially immunogenic, getting aggregation potential, and other reasons, the following 8 variable region framework positions of 18C5 were considered as candidates for substitutions in the 2 exemplified human mature light chain variable regions and the 2 exemplified human mature heavy chain variable regions, as further specified in Example 7: L2 (I2V), L45 (Q45R), H37 (V37A), H45 (L45Q), H47 (L47W), H48 (V48I), H49 (A49G), and H94 (S94R).

[0272] Here, as elsewhere, the first-mentioned residue is the residue of a humanized antibody formed by grafting Kabat CDRs or a composite Chothia Kabat CDR in the case of CDR-H1 into a human acceptor framework, and the second-mentioned residue is a residue being considered for replacing such residue. Thus, within variable region frameworks, the first mentioned residue is human, and within CDRs, the first mentioned residue is mouse.

[0273] Exemplified antibodies include any permutations or combinations of the exemplified mature heavy and light chain variable regions of 18C5 *e.g.*, hu18C5VH_v1/ hu18C5VL_v1, hu18C5VH_v1/ hu18C5VL_v2, hu18C5VH_v2/ hu18C5VL_v1, or hu18C5VH_v2/ hu18C5VL_v2.

[0274] The invention provides variants of the 18C5 humanized antibody in which the humanized mature heavy chain variable region shows at least 90%, 95%, 96%, 97%, 98%, or 99% identity to any one of hu18C5-VH_v1, and hu18C5-VH_v2. (SEQ ID NOs: 85-86) and the humanized mature light chain variable region shows at least 90%, 95%, 96%, 97%, 98%, or 99% identity to any one of hu18C5-VL_v1, and hu18C5-VL_v2, (SEQ ID NOs: 91-92). In some such antibodies at least 1, 2, 3, 4, 5, 6, 7, or all 8, of the backmutations or other mutations found in SEQ ID NO:86 and SEQ ID NO:92 are retained.

[0275] In some humanized 18C5 antibodies, at least one of the following positions is occupied by the amino acid as specified: H37 is occupied by V or A, H45 is occupied by L or Q, H47 is

occupied by L or W, H48 is occupied by L or I, H49 is occupied by A or G, and H94 is occupied by S or R.

[0276] In some humanized 18C5 antibodies, positions H37, H45, H47, H48, H49, and H94 in the VH region are occupied by A, Q, W, I, G, and R, respectively, as in hu18C5-VH_v2.

[0277] In some humanized 18C5 antibodies, at least one of the following positions is occupied by the amino acid as specified: L2 is occupied by I or V and L45 is occupied by Q or R.

[0278] In some humanized 18C5 antibodies, positions L2 and L45 in the VL region are occupied by V and R, respectively, as in hu18C5-VL_v2.

[0279] In some humanized 18C5 antibodies, the variable heavy chain has $\geq 85\%$ identity to human sequence. In some humanized 18C5 antibodies, the variable light chain has $\geq 85\%$ identity to human sequence. In some humanized 18C5 antibodies, each of the variable heavy chain and variable light chain has $\geq 85\%$ identity to human germline sequence.

[0280] The CDR regions of such humanized antibodies can be identical or substantially identical to the CDR regions of the 9D5 or 18C5 mouse donor antibody. The CDR regions can be defined by any conventional definition, such as those in Table 1, but are preferably as defined by Kabat or Kabat+Chothia composite.

[0281] Variable regions framework positions are in accordance with Kabat numbering unless otherwise stated. Other such variants typically differ from the sequences of the exemplified Hu18C5 heavy and light chains by a small number (*e.g.*, typically no more than 1, 2, 3, 5, 10, or 15) of replacements, deletions or insertions.

[0282] A possibility for additional variation in humanized 9D5 or 18C5 variants is additional backmutations in the variable region frameworks. Many of the framework residues not in contact with the CDRs in the humanized mAb can accommodate substitutions of amino acids from the corresponding positions of the donor mouse mAb or other mouse or human antibodies, and even many potential CDR-contact residues are also amenable to substitution. Even amino acids within the CDRs may be altered, for example, with residues found at the corresponding position of the human acceptor sequence used to supply variable region frameworks. In addition,

alternate human acceptor sequences can be used, for example, for the heavy and/or light chain. If different acceptor sequences are used, one or more of the backmutations recommended above may not be performed because the corresponding donor and acceptor residues are already the same without backmutations.

[0283] Some replacements or backmutations in Hu9D5 or Hu18C5 variants (whether or not conservative) have no substantial effect on the binding affinity or potency of the humanized mAb, that is, its ability to bind to monomeric TTR (*e.g.*, the potency in some or all of the assays described in the present examples of the variant humanized 9D5 or 18C5 antibody is essentially the same, *i.e.*, within experimental error, as that of murine 9D5 or murine 18C5). Exemplary humanized 9D5 variants are described in WO 2016/120810.

D. Chimeric and Veneered Antibodies

[0284] The invention further provides chimeric and veneered forms of non-human antibodies, particularly the 9D5 or 18C5 antibodies of the examples.

[0285] A chimeric antibody is an antibody in which the mature variable regions of light and heavy chains of a non-human antibody (*e.g.*, a mouse) are combined with human light and heavy chain constant regions. Such antibodies substantially or entirely retain the binding specificity of the mouse antibody, and are about two-thirds human sequence. In an embodiment, a chimeric 18C5 antibody has a mature heavy chain variable region amino acid sequence of SEQ ID NO:81, a mature light chain variable region amino acid sequence of SEQ ID NO:87, a human heavy chain constant region amino acid sequence of SEQ ID NO: 17, and a human light chain constant region amino acid sequence of SEQ ID NO: 19. An exemplary chimeric 9D5 antibody is described in WO 2016/120810,

[0286] A veneered antibody is a type of humanized antibody that retains some and usually all of the CDRs and some of the non-human variable region framework residues of a non-human antibody but replaces other variable region framework residues that may contribute to B- or T-cell epitopes, for example exposed residues (Padlan, *Mol. Immunol.* 28:489, 1991) with residues from the corresponding positions of a human antibody sequence. The result is an antibody in which the CDRs are entirely or substantially from a non-human antibody and the variable region

frameworks of the non-human antibody are made more human-like by the substitutions.

Veneered forms of the 9D5 or 18C5 antibody are included in the invention.

E. Human Antibodies

[0287] Human antibodies against monomeric TTR or a fragment thereof (*e.g.*, amino acid residues 89-97 (SEQ ID NO:45) of TTR, or amino acid residues 101-109 (SEQ ID NO:30) of TTR) are provided by a variety of techniques described below. Some human antibodies are selected by competitive binding experiments, by the phage display method of Winter, above, or otherwise, to have the same epitope specificity as a particular mouse antibody, such as one of the mouse monoclonal antibodies described in the examples. Human antibodies can also be screened for particular epitope specificity by using only a fragment of TTR, such as a TTR variant containing only amino acid residues 89-97 or amino acid residues 101-109 of TTR, as the target antigen, and/or by screening antibodies against a collection of TTR variants, such as TTR variants containing various mutations within amino acid residues 89-97 or amino acid residues 101-109 of TTR.

[0288] Methods for producing human antibodies include the trioma method of Oestberg *et al.*, *Hybridoma* 2:361-367 (1983); Oestberg, U.S. Patent No. 4,634,664; and Engleman *et al.*, US Patent 4,634,666, use of transgenic mice including human immunoglobulin genes (*see, e.g.*, Lonberg *et al.*, WO93/12227 (1993); US 5,877,397; US 5,874,299; US 5,814,318; US 5,789,650; US 5,770,429; US 5,661,016; US 5,633,425; US 5,625,126; US 5,569,825; US 5,545,806; Neuberger, *Nat. Biotechnol.* 14:826 (1996); and Kucherlapati, WO 91/10741 (1991)) and phage display methods (*see, e.g.*, Dower *et al.*, WO 91/17271; McCafferty *et al.*, WO 92/01047; US 5,877,218; US 5,871,907; US 5,858,657; US 5,837,242; US 5,733,743; and US 5,565,332).

F. Selection of Constant Region

[0289] The heavy and light chain variable regions of chimeric, veneered or humanized antibodies can be linked to at least a portion of a human constant region. The choice of constant region depends, in part, whether antibody-dependent cell-mediated cytotoxicity, antibody dependent cellular phagocytosis and/or complement dependent cytotoxicity are desired. For example, human isotypes IgG1 and IgG3 have complement-dependent cytotoxicity and human

isotypes IgG2 and IgG4 do not. Human IgG1 and IgG3 also induce stronger cell mediated effector functions than human IgG2 and IgG4. Light chain constant regions can be lambda or kappa. Numbering conventions for constant regions include EU numbering (Edelman, G.M. et al., Proc. Natl. Acad. USA, 63, 78-85 (1969)), Kabat numbering (Kabat, *Sequences of Proteins of Immunological Interest* (National Institutes of Health, Bethesda, MD, 1991, IMGT unique numbering (Lefranc M.-P. et al., IMGT unique numbering for immunoglobulin and T cell receptor constant domains and Ig superfamily C-like domains, Dev. Comp. Immunol., 29, 185-203 (2005), and IMGT exon numbering (Lefranc, supra).

[0290] One or several amino acids at the amino or carboxy terminus of the light and/or heavy chain, such as the C-terminal lysine of the heavy chain, may be missing or derivatized in a proportion or all of the molecules. Substitutions can be made in the constant regions to reduce or increase effector function such as complement-mediated cytotoxicity or ADCC (*see, e.g.,* Winter *et al.*, US Patent No. 5,624,821; Tso *et al.*, US Patent No. 5,834,597; and Lazar *et al.*, Proc. Natl. Acad. Sci. USA 103:4005, 2006), or to prolong half-life in humans (*see, e.g.,* Hinton *et al.*, J. Biol. Chem. 279:6213, 2004). Exemplary substitutions include a Gln at position 250 and/or a Leu at position 428 (EU numbering is used in this paragraph for the constant region) for increasing the half-life of an antibody. Substitution at any or all of positions 234, 235, 236 and/or 237 reduce affinity for Fcγ receptors, particularly FcγRI receptor (*see, e.g.,* US 6,624,821). An alanine substitution at positions 234, 235, and 237 of human IgG1 can be used for reducing effector functions. Some antibodies have alanine substitution at positions 234, 235 and 237 of human IgG1 for reducing effector functions. Optionally, positions 234, 236 and/or 237 in human IgG2 are substituted with alanine and position 235 with glutamine (*see, e.g.,* US 5,624,821). In some antibodies, a mutation at one or more of positions 241, 264, 265, 270, 296, 297, 322, 329, and 331 by EU numbering of human IgG1 is used. In some antibodies, a mutation at one or more of positions 318, 320, and 322 by EU numbering of human IgG1 is used. In some antibodies, positions 234 and/or 235 are substituted with alanine and/or position 329 is substituted with glycine. In some antibodies, positions 234 and 235 are substituted with alanine, such as in SEQ ID NO:23. In some antibodies, the isotype is human IgG2 or IgG4.

[0291] An exemplary human light chain kappa constant region has the amino acid sequence of SEQ ID NO:24. The N-terminal arginine of SEQ ID NO:24 can be omitted, in which case light

chain kappa constant region has the amino acid sequence of SEQ ID NO:25. An exemplary human IgG1 heavy chain constant region has the amino acid sequence of SEQ ID NO:21 (with or without the C-terminal lysine). Antibodies can be expressed as tetramers containing two light and two heavy chains, as separate heavy chains, light chains, as Fab, Fab', F(ab')₂, and Fv, or as single chain antibodies in which heavy and light chain mature variable domains are linked through a spacer.

[0292] Human constant regions show allotypic variation and isoallotypic variation between different individuals, that is, the constant regions can differ in different individuals at one or more polymorphic positions. Isoallotypes differ from allotypes in that sera recognizing an isoallotype bind to a non-polymorphic region of a one or more other isotypes. Thus, for example, another heavy chain constant region is of IgG1 G1m3 allotype and has the amino acid sequence of SEQ ID NO:22. Another heavy chain constant region of the IgG1 G1m3 allotype has the amino acid sequence of SEQ ID NO:23 (with or without the C-terminal lysine). Reference to a human constant region includes a constant region with any natural allotype or any permutation of residues occupying positions in natural allotypes.

G. Expression of Recombinant Antibodies

[0293] A number of methods are known for producing chimeric and humanized antibodies using an antibody-expressing cell line (*e.g.*, hybridoma). For example, the immunoglobulin variable regions of antibodies can be cloned and sequenced using well known methods. In one method, the heavy chain variable VH region is cloned by RT-PCR using mRNA prepared from hybridoma cells. Consensus primers are employed to the VH region leader peptide encompassing the translation initiation codon as the 5' primer and a g2b constant regions specific 3' primer. Exemplary primers are described in U.S. patent publication US 2005/0009150 by Schenk *et al.* (hereinafter "Schenk"). The sequences from multiple, independently derived clones can be compared to ensure no changes are introduced during amplification. The sequence of the VH region can also be determined or confirmed by sequencing a VH fragment obtained by 5' RACE RT-PCR methodology and the 3' g2b specific primer.

[0294] The light chain variable VL region can be cloned in an analogous manner. In one approach, a consensus primer set is designed for amplification of VL regions using a 5' primer

designed to hybridize to the VL region encompassing the translation initiation codon and a 3' primer specific for the Ck region downstream of the V-J joining region. In a second approach, 5'RACE RT-PCR methodology is employed to clone a VL encoding cDNA. Exemplary primers are described in Schenk, supra. The cloned sequences are then combined with sequences encoding human (or other non-human species) constant regions. Exemplary sequences encoding human constant regions include SEQ ID NO:32, which encodes a human IgG1 constant region, and SEQ ID NOs:33 and 34, which encode a human kappa light chain constant region.

[0295] In one approach, the heavy and light chain variable regions are re-engineered to encode splice donor sequences downstream of the respective VDJ or VJ junctions and are cloned into a mammalian expression vector, such as pCMV- γ 1 for the heavy chain and pCMV-M κ 1 for the light chain. These vectors encode human γ 1 and Ck constant regions as exonic fragments downstream of the inserted variable region cassette. Following sequence verification, the heavy chain and light chain expression vectors can be co-transfected into CHO cells to produce chimeric antibodies. Conditioned media is collected 48 hours post-transfection and assayed by western blot analysis for antibody production or ELISA for antigen binding. The chimeric antibodies are humanized as described above.

[0296] Chimeric, veneered, humanized, and human antibodies are typically produced by recombinant expression. Recombinant polynucleotide constructs typically include an expression control sequence operably linked to the coding sequences of antibody chains, including naturally associated or heterologous expression control elements, such as a promoter. The expression control sequences can be promoter systems in vectors capable of transforming or transfecting eukaryotic or prokaryotic host cells. Once the vector has been incorporated into the appropriate host, the host is maintained under conditions suitable for high level expression of the nucleotide sequences and the collection and purification of the crossreacting antibodies.

[0297] These expression vectors are typically replicable in the host organisms either as episomes or as an integral part of the host chromosomal DNA. Commonly, expression vectors contain selection markers, *e.g.*, ampicillin resistance or hygromycin resistance, to permit detection of those cells transformed with the desired DNA sequences.

[0298] *E. coli* is one prokaryotic host useful for expressing antibodies, particularly antibody fragments. Microbes, such as yeast, are also useful for expression. *Saccharomyces* is a yeast host with suitable vectors having expression control sequences, an origin of replication, termination sequences, and the like as desired. Typical promoters include 3-phosphoglycerate kinase and other glycolytic enzymes. Inducible yeast promoters include, among others, promoters from alcohol dehydrogenase, isocytochrome C, and enzymes responsible for maltose and galactose utilization.

[0299] Mammalian cells can be used for expressing nucleotide segments encoding immunoglobulins or fragments thereof. *See* Winnacker, *From Genes to Clones*, (VCH Publishers, NY, 1987). A number of suitable host cell lines capable of secreting intact heterologous proteins have been developed, and include CHO cell lines, various COS cell lines, HeLa cells, HEK293 cells, L cells, and non-antibody-producing myelomas including Sp2/0 and NS0. The cells can be nonhuman. Expression vectors for these cells can include expression control sequences, such as an origin of replication, a promoter, an enhancer (Queen *et al.*, *Immunol. Rev.* 89:49 (1986)), and necessary processing information sites, such as ribosome binding sites, RNA splice sites, polyadenylation sites, and transcriptional terminator sequences. Expression control sequences can include promoters derived from endogenous genes, cytomegalovirus, SV40, adenovirus, bovine papillomavirus, and the like. *See* Co *et al.*, *J. Immunol.* 148:1149 (1992).

[0300] Alternatively, antibody coding sequences can be incorporated in transgenes for introduction into the genome of a transgenic animal and subsequent expression in the milk of the transgenic animal (*see, e.g.*, U.S. Pat. No. 5,741,957; U.S. Pat. No. 5,304,489; and U.S. Pat. No. 5,849,992). Suitable transgenes include coding sequences for light and/or heavy chains operably linked with a promoter and enhancer from a mammary gland specific gene, such as casein or beta lactoglobulin.

[0301] The vectors containing the DNA segments of interest can be transferred into the host cell by methods depending on the type of cellular host. For example, calcium chloride transfection is commonly utilized for prokaryotic cells, whereas calcium phosphate treatment, electroporation, lipofection, biolistics, or viral-based transfection can be used for other cellular hosts. Other

methods used to transform mammalian cells include the use of polybrene, protoplast fusion, liposomes, electroporation, and microinjection. For production of transgenic animals, transgenes can be microinjected into fertilized oocytes or can be incorporated into the genome of embryonic stem cells, and the nuclei of such cells transferred into enucleated oocytes.

[0302] Having introduced vector(s) encoding antibody heavy and light chains into cell culture, cell pools can be screened for growth productivity and product quality in serum-free media. Top-producing cell pools can then be subjected of FACS-based single-cell cloning to generate monoclonal lines. Specific productivities above 50 pg or 100 pg per cell per day, which correspond to product titers of greater than 7.5 g/L culture, can be used. Antibodies produced by single cell clones can also be tested for turbidity, filtration properties, PAGE, IEF, UV scan, HP-SEC, carbohydrate-oligosaccharide mapping, mass spectrometry, and binding assay, such as ELISA or Biacore. A selected clone can then be banked in multiple vials and stored frozen for subsequent use.

[0303] Once expressed, antibodies can be purified according to standard procedures of the art, including protein A capture, HPLC purification, column chromatography, gel electrophoresis and the like (*see generally*, Scopes, *Protein Purification* (Springer-Verlag, NY, 1982)).

[0304] Methodology for commercial production of antibodies can be employed, including codon optimization, selection of promoters, selection of transcription elements, selection of terminators, serum-free single cell cloning, cell banking, use of selection markers for amplification of copy number, CHO terminator, or improvement of protein titers (*see, e.g.*, US 5,786,464; US 6,114,148; US 6,063,598; US 7,569,339; W02004/050884; W02008/012142; W02008/012142; W02005/019442; W02008/107388; W02009/027471; and US 5,888,809).

H. Antibody Screening Assays

[0305] Antibodies can be subject to several screens including binding assays, functional screens, screens in animal models of diseases associated with TTR deposits, and clinical trials. Binding assays test for specific binding and, optionally, affinity and epitope specificity to monomeric TTR or a fragment thereof. For example, binding assays can screen for antibodies that bind to amino acid residues 89-97 (SEQ ID NO:45) or amino acid residues 101-109 (SEQ ID NO:30) of

TTR, which are epitopes that are buried in the native TTR tetramer and exposed in monomeric, misfolded, aggregated, or fibril forms of TTR. Antibodies can also be screened for the ability to bind pre-fibrillar, non-native conformations of TTR and TTR amyloid fibrils but not native TTR conformations. For example, antibodies can be screened for the ability to bind to monomeric forms of TTR created by dissociation or disaggregation of native tetrameric TTR, and can be counter-screened against native tetrameric TTR, as described in the examples or otherwise. Likewise, antibodies can also be screened for their immunoreactivity on TTR-mediated amyloidosis tissue but not on healthy tissue. Such screens are sometimes performed in competition with an exemplary antibody, such as an antibody having the variable regions of 9D5 or of 18C5 or IgG1 kappa isotype. Optionally, either the antibody or TTR target is immobilized in such assay.

[0306] Functional assays can be performed in cellular models including cells naturally expressing TTR or transfected with DNA encoding TTR or a fragment thereof. Suitable cells include cells derived from cardiac tissue or other tissues affected by TTR amyloidogenesis. Cells can be screened for reduced levels of monomeric, misfolded, aggregated, or fibril forms of TTR (*e.g.*, by Western blotting or immunoprecipitation of cell extracts or supernatants) or reduced toxicity attributable to monomeric, misfolded, aggregated, or fibril forms of TTR. For example, antibodies can be tested for the ability to inhibit or reduce aggregation of TTR, inhibit or reduce TTR fibril formation, reduce TTR deposits, clear aggregated TTR, or stabilize non-toxic conformations of TTR.

[0307] Other functional assays can be performed in solution, such as testing whether an antibody is capable of disrupting or reducing TTR fibril formation when monomeric TTR or misfolded TTR intermediates in solution are contacted with the antibody. The extent of fibril formation can be probed by turbidity measurements, for example, at 400 nm on a UV-visible spectrometer equipped with a temperature control unit. Thioflavin-T can also be used to assess the extent of amyloid fibril formation. For example, a five-fold molar excess of Thioflavin-T can be added to TTR samples and left at room temperature for 30 minutes before measurements are taken. Thioflavin-T fluorescence can be monitored using a spectrofluorimeter. *See* US 2014/0056904.

[0308] Animal model screens test the ability of the antibody to therapeutically or prophylactically treat signs or symptoms in an animal model simulating a human disease associated with accumulation of TTR or TTR deposits. Such diseases include types of TTR amyloidosis, such as wild-type ATTR amyloidosis (also called senile systemic amyloidosis SSA), senile cardiac amyloidosis (SCA), familial amyloid polyneuropathy (FAP), familial amyloid cardiomyopathy (FAC), and central nervous system selective amyloidosis (CNSA). Suitable signs or symptoms that can be monitored include the presence and extent of amyloid deposits in various tissues, such as the gastrointestinal tract or heart. The extent of reduction of amyloid deposits can be determined by comparison with an appropriate control, such the level of TTR amyloid deposits in control animals that have received a control antibody (*e.g.*, an isotype matched control antibody), a placebo, or no treatment at all. An exemplary animal model for testing activity against a TTR amyloidosis is a mouse model carrying a null mutation at the endogenous mouse *Ttr* locus and the human mutant *TTR* gene comprising a V30M mutation that is associated with familial amyloidotic polyneuropathy. *See, e.g.*, Kohno *et al.*, *Am. J. Path.* 150(4):1497-1508 (1997); Cardoso and Saraiva, *FASEB J* 20(2):234-239 (2006). Similar models also exist, including other models for familial versions of TTR amyloidosis and models for sporadic versions of TTR amyloidosis. *See, e.g.*, Teng *et al.*, *Lab. Invest.* 81(3): 385-396 (2001); Ito and Maeda, *Mouse Models of Transthyretin Amyloidosis*, in *Recent Advances in Transthyretin Evolution, Structure, and Biological Functions*, pp. 261-280 (2009) (Springer Berlin Heidelberg). Transgenic animals can include a human TTR transgene, such as a TTR transgene with a mutation associated with TTR amyloidosis or a wild-type TTR transgene. To facilitate testing in animal models, chimeric antibodies having a constant region appropriate for the animal model can be used (*e.g.*, mouse-rat chimeras could be used for testing antibodies in rats). It can be concluded that a humanized version of an antibody will be effective if the corresponding mouse antibody or chimeric antibody is effective in an appropriate animal model and the humanized antibody has similar binding affinity (*e.g.*, within experimental error, such as by a factor of 1.5, 2, or 3).

[0309] Clinical trials test for safety and efficacy in a human having a disease associated with TTR amyloidosis.

I. Nucleic Acids

[0310] The invention further provides nucleic acids encoding any of the heavy and light chains described above (*e.g.*, SEQ ID NOs: 2, 4, 18, and 20). Optionally, such nucleic acids further encode a signal peptide and can be expressed with the signal peptide linked to the constant region (*e.g.*, signal peptides having amino acid sequences of SEQ ID NOs:35 (heavy chain) and 37 (light chain) that can be encoded by SEQ ID NOs:36 (heavy chain) and 38 (light chain), respectively. Coding sequences of nucleic acids can be operably linked with regulatory sequences to ensure expression of the coding sequences, such as a promoter, enhancer, ribosome binding site, transcription termination signal, and the like. The nucleic acids encoding heavy and light chains can occur in isolated form or can be cloned into one or more vectors. The nucleic acids can be synthesized by, for example, solid state synthesis or PCR of overlapping oligonucleotides. Nucleic acids encoding heavy and light chains can be joined as one contiguous nucleic acid, *e.g.*, within an expression vector, or can be separate, *e.g.*, each cloned into its own expression vector.

J. Conjugated Antibodies

[0311] Conjugated antibodies that specifically bind to antigens exposed in pathogenic forms of TTR but not in native tetrameric form of TTR, such as amino acid residues 89-97 (SEQ ID NO:45) or amino acid residues 101-109 (SEQ ID NO:30) of TTR, are useful in detecting the presence of monomeric, misfolded, aggregated, or fibril forms of TTR; monitoring and evaluating the efficacy of therapeutic agents being used to treat patients diagnosed with a TTR amyloidosis; inhibiting or reducing aggregation of TTR; inhibiting or reducing TTR fibril formation; reducing or clearing TTR deposits; stabilizing non-toxic conformations of TTR; or treating or effecting prophylaxis of a TTR amyloidosis in a patient. For example, such antibodies can be conjugated with other therapeutic moieties, other proteins, other antibodies, and/or detectable labels. *See* WO 03/057838; US 8,455,622.

[0312] Conjugated therapeutic moieties can be any agent that can be used to treat, combat, ameliorate, prevent, or improve an unwanted condition or disease in a patient, such as a TTR amyloidosis. Therapeutic moieties can include, for example, immunomodulators or any biologically active agents that facilitate or enhance the activity of the antibody. An

immunomodulator can be any agent that stimulates or inhibits the development or maintenance of an immunologic response. If such therapeutic moieties are coupled to an antibody specific for monomeric, misfolded, aggregated, or fibril forms of TTR, such as the antibodies described herein, the coupled therapeutic moieties will have a specific affinity for non-native, pathogenic forms of TTR over native tetrameric form of TTR. Consequently, administration of the conjugated antibodies directly targets tissues comprising pathogenic forms of TTR with minimal damage to surrounding normal, healthy tissue. This can be particularly useful for therapeutic moieties that are too toxic to be administered on their own. In addition, smaller quantities of the therapeutic moieties can be used.

[0313] Examples of suitable therapeutic moieties include drugs that reduce levels of TTR, stabilize the native tetrameric structure of TTR, inhibit aggregation of TTR, disrupt TTR fibril or amyloid formation, or counteract cellular toxicity. *See, e.g.,* Almeida and Saraiva, *FEBS Letters* 586:2891-2896 (2012); Saraiva, *FEBS Letters* 498:201-203 (2001); Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013); Ruberg and Berk, *Circulation* 126:1286-1300 (2012); Johnson *et al.*, *J. Mol. Biol.* 421(2-3):185-203 (2012, Ueda and Ando, *Translational Neurodegeneration* 3:19 (2014), and Hawkins *et al.* *Annals of Medicine* 47:625-638 (2015)). For example, antibodies can be conjugated to tafamidis, diflunisal, AG10, ALN-TTR01, ALNTTR02, antisense oligonucleotides such as IONIS TTRRx (inotersen), siRNAs such as patisiran or revusiran, doxycycline (doxy), tauroursodeoxycholic acid (TUDCA), Doxy-TUDCA, cyclodextrin (CyD), 4'-iodo-4'-deoxydoxorubicin (IDOX), epigallocatechin gallate (EGCG), curcumin, resveratrol (3,5,4'-trihydroxystilbene), or antibodies to serum amyloid P component (SAP). Other representative therapeutic moieties include other agents known to be useful for treatment, management, or amelioration of a TTR amyloidosis or symptoms of a TTR amyloidosis. *See, e.g.,* Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013) for common clinical symptoms of TTR amyloidosis and typical agents used to treat those symptoms.

[0314] Antibodies can also be coupled with other proteins. For example, antibodies can be coupled with Fynomers. Fynomers are small binding proteins (*e.g.*, 7 kDa) derived from the human Fyn SH3 domain. They can be stable and soluble, and they can lack cysteine residues and disulfide bonds. Fynomers can be engineered to bind to target molecules with the same affinity and specificity as antibodies. They are suitable for creating multi-specific fusion

proteins based on antibodies. For example, Fynomers can be fused to N-terminal and/or C-terminal ends of antibodies to create bi- and tri-specific FynomAbs with different architectures. Fynomers can be selected using Fynomer libraries through screening technologies using FACS, Biacore, and cell-based assays that allow efficient selection of Fynomers with optimal properties. Examples of Fynomers are disclosed in Grabulovski *et al.*, *J. Biol. Chem.* 282:3196-3204 (2007); Bertschinger *et al.*, *Protein Eng. Des. Sel.* 20:57-68 (2007); Schlatter *et al.*, *MAbs.* 4:497-508 (2011); Banner *et al.*, *Acta. Crystallogr. D. Biol. Crystallogr.* 69(Pt6):1124-1137 (2013); and Brack *et al.*, *Mol. Cancer Ther.* 13:2030-2039 (2014).

[0315] The antibodies disclosed herein can also be coupled or conjugated to one or more other antibodies (*e.g.*, to form antibody heteroconjugates). Such other antibodies can bind to different epitopes within TTR or a portion thereof or can bind to a different target antigen. Such anti-TTR antibodies binding to TTR epitopes different from that of 9D5 or 18C5, may include antibodies as in Table 3.

[0316] Antibodies can also be coupled with a detectable label. Such antibodies can be used, for example, for diagnosing a TTR amyloidosis, for monitoring progression of a TTR amyloidosis, and/or for assessing efficacy of treatment. Such antibodies are particularly useful for performing such determinations in subjects having or being susceptible to a TTR amyloidosis, or in appropriate biological samples obtained from such subjects. Representative detectable labels that may be coupled or linked to an antibody disclosed herein include various enzymes, such as horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; prosthetic groups, such streptavidin, avidin or biotin; fluorescent materials, such as umbelliferone, DyLight fluors, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; luminescent materials, such as luminol; bioluminescent materials, such as luciferase, luciferin, and aequorin; radioactive materials, such as yttrium⁹⁰ (90Y), radiosilver-111, radiosilver-199, Bismuth²¹³, iodine (¹³¹I, ¹²⁵I, ¹²³I, ¹²¹I), carbon (¹⁴C), sulfur (³⁵S), tritium (³H), indium (¹¹⁵In, ¹¹³In, ¹¹²In, ¹¹¹In), technetium (⁹⁹Tc), thallium (²⁰¹Tl), gallium (⁶⁸Ga, ⁶⁷Ga), palladium (¹⁰³Pd), molybdenum (⁹⁹Mo), xenon (¹³³Xe), fluorine (¹⁸F), ¹⁵³Sm, ¹⁷⁷Lu, ¹⁵⁹Gd, ¹⁴⁹Pm, ¹⁴⁰La, ¹⁷⁵Yb, ¹⁶⁶Ho, ⁹⁰Y, ⁴⁷Sc, ¹⁸⁶Re, ¹⁸⁸Re, ¹⁴²Pr, ¹⁰⁵Rh, ⁹⁷Ru, ⁶⁸Ge, ⁵⁷Co, ⁶⁵Zn, ⁸⁵Sr, ³²P, ¹⁵³Gd, ¹⁶⁹Yb, ⁵¹Cr, ⁵⁴Mn, ⁷⁵Se, ¹¹³Sn, and ¹¹⁷Tm; positron emitting metals using various positron emission tomographies; nonradioactive

paramagnetic metal ions; and molecules that are radiolabelled or conjugated to specific radioisotopes. Representative detectable labels that may be coupled or linked to an antibody disclosed herein include electrochemiluminescent labels, for example MSD GOLD SULFO-TAG NHS-Ester (SULFO-TAG) (Meso Scale Diagnostics, Rockville, MD).

[0317] Linkage of radioisotopes to antibodies may be performed with conventional bifunction chelates. For radiosilver-111 and radiosilver-199 linkage, sulfur-based linkers may be used. *See Hazra et al., Cell Biophys.* 24-25:1-7 (1994). Linkage of silver radioisotopes may involve reducing the immunoglobulin with ascorbic acid. For radioisotopes such as 111In and 90Y, ibritumomab tiuxetan can be used and will react with such isotopes to form 111In-ibritumomab tiuxetan and 90Y-ibritumomab tiuxetan, respectively. *See Witzig, Cancer Chemother. Pharmacol.*, 48 Suppl 1:S91-S95 (2001).

[0318] Therapeutic moieties, other proteins, other antibodies, and/or detectable labels may be coupled or conjugated, directly or indirectly through an intermediate (*e.g.*, a linker), to a murine, chimeric, veneered, or humanized 9D5 or 18C5 antibody using techniques known in the art. *See e.g., Arnon et al., "Monoclonal Antibodies For Immunotargeting Of Drugs In Cancer Therapy," in Monoclonal Antibodies And Cancer Therapy, Reisfeld et al. (eds.), pp. 243-56 (Alan R. Liss, Inc. 1985); Hellstrom et al., "Antibodies For Drug Delivery," in Controlled Drug Delivery (2nd Ed.), Robinson et al. (eds.), pp. 623-53 (Marcel Dekker, Inc. 1987); Thorpe, "Antibody Carriers Of Cytotoxic Agents In Cancer Therapy: A Review," in Monoclonal Antibodies 84: Biological And Clinical Applications, Pinchera et al. (eds.), pp. 475-506 (1985); "Analysis, Results, And Future Prospective Of The Therapeutic Use Of Radiolabeled Antibody In Cancer Therapy," in Monoclonal Antibodies For Cancer Detection And Therapy, Baldwin et al. (eds.), pp. 303-16 (Academic Press 1985); and Thorpe et al., Immunol. Rev., 62:119-58 (1982).* Suitable linkers include, for example, cleavable and non-cleavable linkers. Different linkers that release the coupled therapeutic moieties, proteins, antibodies, and/or detectable labels under acidic or reducing conditions, on exposure to specific proteases, or under other defined conditions can be employed.

V. Therapeutic Applications

[0319] The above antibodies can be used for treating or effecting prophylaxis of a disease in a patient having or at risk for the disease mediated at least in part by transthyretin (TTR), and particularly by monomeric, misfolded, aggregated, or fibril forms of TTR. Although an understanding of mechanism is not required for practice, it is believed that any or all of the following mechanisms may contribute to treatment of TTR amyloidosis using the above antibodies: antibody-mediated inhibition of TTR aggregation and fibril formation, antibody-mediated stabilization of non-toxic conformations of TTR (*e.g.*, tetrameric forms), or antibody-mediated clearance of aggregated TTR, oligomeric TTR, or monomeric TTR. Antibody-drug conjugates can have additional mechanisms of action determined by the conjugated moiety.

[0320] Antibodies are administered in an effective regime meaning a dosage, route of administration and frequency of administration that delays the onset, reduces the severity, inhibits further deterioration, and/or ameliorates at least one sign or symptom of a disorder being treated. If a patient is already suffering from a disorder, the regime can be referred to as a therapeutically effective regime. If the patient is at elevated risk of the disorder relative to the general population but is not yet experiencing symptoms, the regime can be referred to as a prophylactically effective regime. In some instances, therapeutic or prophylactic efficacy can be observed in an individual patient relative to historical controls or past experience in the same patient. In other instances, therapeutic or prophylactic efficacy can be demonstrated in a preclinical or clinical trial in a population of treated patients relative to a control population of untreated patients.

[0321] The frequency of administration depends on the half-life of the antibody in the circulation, the condition of the patient and the route of administration among other factors. The frequency can be daily, weekly, monthly, quarterly, or at irregular intervals in response to changes in the patient's condition or progression of the disorder being treated. An exemplary frequency for intravenous administration is between weekly and quarterly over a continuous course of treatment, although more or less frequent dosing is also possible. For subcutaneous administration, an exemplary dosing frequency is daily to monthly, although more or less frequent dosing is also possible.

[0322] The number of dosages administered depends on whether the disorder is acute or chronic and the response of the disorder to the treatment. For acute disorders or acute exacerbations of a chronic disorder, between 1 and 10 doses are often sufficient. Sometimes a single bolus dose, optionally in divided form, is sufficient for an acute disorder or acute exacerbation of a chronic disorder. Treatment can be repeated for recurrence of an acute disorder or acute exacerbation. For chronic disorders, an antibody can be administered at regular intervals, *e.g.*, weekly, fortnightly, monthly, quarterly, every six months for at least 1, 5 or 10 years, or the life of the patient.

VI. Pharmaceutical Compositions and Methods of Use

[0323] Provided herein are several methods of diagnosing, monitoring, treating or effecting prophylaxis of diseases or conditions mediated at least in part by transthyretin (TTR), and particularly by monomeric, misfolded, aggregated, or fibril forms of TTR (*e.g.*, TTR amyloidosis). Examples of such diseases include familial TTR amyloidoses, such as familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA), and sporadic TTR amyloidoses, such as senile systemic amyloidosis (SSA) or senile cardiac amyloidosis (SCA). Antibodies described above can be incorporated into a pharmaceutical composition for use in such methods. In general, an antibody or pharmaceutical composition containing an antibody is administered to a subject in need thereof. Patients amenable to treatment include individuals at risk of TTR amyloidosis but not showing symptoms, as well as patients presently showing symptoms. Some patients can be treated during the prodromal stage of TTR amyloidosis.

[0324] The pharmaceutical compositions can be administered prophylactically to individuals who have a known genetic risk of TTR amyloidosis. Such individuals include those having relatives who have experienced such a disease, and those whose risk is determined by analysis of genetic or biochemical markers (*e.g.*, mutations in TTR associated with TTR amyloidosis), including using the diagnostic methods provided herein. For example, there are over 100 mutations in the gene encoding TTR that have been implicated in TTR amyloidosis. *See, e.g.*, US 2014/0056904; Saraiva, *Hum. Mutat.* 17(6):493-503 (2001); Damas and Saraiva, *J. Struct. Biol.* 130:290-299; Dwulet and Benson, *Biochem. Biophys. Res. Commun.* 114:657-662 (1983).

[0325] Individuals suffering from TTR amyloidosis can sometimes be recognized from the clinical manifestations of TTR amyloidosis, including one or more of the following: (1) family history of neuropathic disease, especially associated with heart failure; (2) neuropathic pain or progressive sensory disturbances of unknown etiology; (3) carpal tunnel syndrome without obvious cause, particularly if it is bilateral and requires surgical release; (4) gastrointestinal motility disturbances or autonomic nerve dysfunction of unknown etiology (*e.g.*, erectile dysfunction, orthostatic hypotension, neurogenic bladder); (5) cardiac disease characterized by thickened ventricular walls in the absence of hypertension; (6) advanced atrio-ventricular block of unknown origin, particularly when accompanied by a thickened heart; and (6) vitreous body inclusions of the cotton-wool type. See Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013). Definitive diagnosis of TTR amyloidosis, however, typically relies on target organ biopsies, followed by histological staining of the excised tissue with the amyloid-specific dye, Congo red. If a positive test for amyloid is observed, immunohistochemical staining and mass spectroscopic identification of TTR are subsequently performed to ensure that the precursor protein responsible for amyloid formation is indeed TTR. For familial forms of the diseases, demonstration of a mutation in the gene encoding TTR is then needed before a definitive diagnosis can be made.

[0326] The identification of the subject can occur in a clinical setting, or elsewhere, such as in the subject's home, for example, through the subject's own use of a self-testing kit. For example, the subject can be identified based on various symptoms such as peripheral neuropathy (sensory and motor), autonomic neuropathy, gastrointestinal impairment, cardiomyopathy, nephropathy, or ocular deposition. See Ando *et al.*, *Orphanet Journal of Rare Diseases* 8:31 (2013). The subject can also be identified by increased levels of non-native forms of TTR in plasma samples from the subject compared to control samples, as disclosed in the examples.

[0327] As warranted by family history, genetic testing, or medical screening for TTR amyloidosis, treatment can begin at any age (*e.g.*, 20, 30, 40, 50, 60, or 70 years of age). Treatment typically entails multiple dosages over a period of time and can be monitored by assaying antibody or activated T-cell or B-cell responses to a therapeutic agent (*e.g.*, a truncated form of TTR comprising amino acid residues 89-97 or comprising amino acid residues 101-109) over time. If the response falls, a booster dosage is indicated.

[0328] In prophylactic applications, an antibody or a pharmaceutical composition of the same is administered to a subject susceptible to, or otherwise at risk of a disease (*e.g.*, TTR amyloidosis) in a regime (dose, frequency and route of administration) effective to reduce the risk, lessen the severity, or delay the onset of at least one sign or symptom of the disease. In therapeutic applications, an antibody or immunogen to induce an antibody is administered to a subject suspected of, or already suffering from a disease (*e.g.*, TTR amyloidosis) in a regime (dose, frequency and route of administration) effective to ameliorate or at least inhibit further deterioration of at least one sign or symptom of the disease.

[0329] A regime is considered therapeutically or prophylactically effective if an individual treated subject achieves an outcome more favorable than the mean outcome in a control population of comparable subjects not treated by methods disclosed herein, or if a more favorable outcome is demonstrated for a regime in treated subjects versus control subjects in a controlled clinical trial (*e.g.*, a phase II, phase II/III, or phase III trial) or an animal model at the $p < 0.05$ or 0.01 or even 0.001 level.

[0330] An effective regime of an antibody can be used for, *e.g.*, inhibiting or reducing aggregation of TTR in a subject having or at risk of a condition associated with TTR accumulation; inhibiting or reducing TTR fibril formation in a subject having or at risk of a condition associated with TTR accumulation; reducing or clearing TTR deposits or aggregated TTR in a subject having or at risk of a condition associated with TTR accumulation; stabilizing non-toxic conformations of TTR in a subject having or at risk of a condition associated with TTR accumulation; inhibiting toxic effects of TTR aggregates, fibrils or deposits in a subject having or at risk of a condition associated with TTR accumulation; diagnosing the presence or absence of TTR amyloid accumulation in a tissue suspected of comprising the amyloid accumulation; determining a level of TTR deposits in a subject by detecting the presence of bound antibody in the subject following administration of the antibody; detecting the presence of monomeric, misfolded, aggregated, or fibril forms of TTR in a subject; monitoring and evaluating the efficacy of therapeutic agents being used to treat patients diagnosed with a TTR amyloidosis; inducing an immune response comprising antibodies to TTR in a subject; delaying the onset of a condition associated with TTR amyloid accumulation in a subject; or treating or effecting prophylaxis of a TTR amyloidosis in a patient.

[0331] Effective doses vary depending on many different factors, such as means of administration, target site, physiological state of the subject, whether the subject is human or an animal, other medications administered, and whether treatment is prophylactic or therapeutic.

[0332] An exemplary dose range for antibodies can be from about 0.1-20, or 0.5-5 mg/kg body weight (*e.g.*, 0.5, 1, 2, 3, 4 or 5 mg/kg) or 10-1500 mg as a fixed dosage. The dosage depends on the condition of the patient and response to prior treatment, if any, whether the treatment is prophylactic or therapeutic and whether the disorder is acute or chronic, among other factors.

[0333] Antibody can be administered in such doses daily, on alternative days, weekly, fortnightly, monthly, quarterly, or according to any other schedule determined by empirical analysis. An exemplary treatment entails administration in multiple doses over a prolonged period, for example, of at least six months. Additional exemplary treatment regimes entail administration once per every two weeks or once a month or once every 3 to 6 months.

[0334] Antibodies can be administered via a peripheral route. Routes of administration include topical, intravenous, oral, subcutaneous, intraarterial, intracranial, intrathecal, intraperitoneal, intranasal or intramuscular. Routes for administration of antibodies can be intravenous or subcutaneous. Intravenous administration can be, for example, by infusion over a period such as 30-90 min. This type of injection is most typically performed in the arm or leg muscles. In some methods, agents are injected directly into a particular tissue where deposits have accumulated, for example intracranial injection.

[0335] Pharmaceutical compositions for parenteral administration can be sterile and substantially isotonic (250-350 mOsm/kg water) and manufactured under GMP conditions. Pharmaceutical compositions can be provided in unit dose form (*i.e.*, the dose for a single administration). Pharmaceutical compositions can be formulated using one or more physiologically acceptable carriers, diluents, excipients or auxiliaries. The formulation depends on the route of administration chosen. For injection, antibodies can be formulated in aqueous solutions, *e.g.*, in physiologically compatible buffers such as Hank's solution, Ringer's solution, or physiological saline or acetate buffer (to reduce discomfort at the site of injection). The solution can contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Alternatively

antibodies can be in lyophilized form for constitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water, before use.

[0336] The regimes can be administered in combination with, concomitantly with, or sequentially with another agent effective in treatment or prophylaxis of the disease being treated. Such agents can include siRNA to inhibit expression of TTR or Vyndaqel, a stabilizer of TTR in tetramer formation. Such agents can include TTR tetramer stabilizers such as tafamidis or diflunisal (see, *e.g.*, WO2011116123, US Patent No. 9,150,489), gene therapies to suppress TTR expression such as antisense oligonucleotides such as IONIS-TTRRx (inotersen) (see, *e.g.*, U.S. Patent Nos. 8,101,743, 8,697,860, 9,061,044, and 9,399,774; Japanese Patent No. JP5896175) or siRNAs such as patisiran or revusiran (see, *e.g.*, WO2016033326), amyloid degrader compounds such as doxycycline (doxy), tauroursodeoxycholic acid (TUDCA), Doxy-TUDCA, cyclodextrin (CyD), 4'-iodo-4'-deoxydoxorubicin (IDOX), or antibodies to serum amyloid P component (SAP).

[0337] Another agent effective in treatment or prophylaxis of the disease being treated may be administered to a subject who has previously been treated with an antibody disclosed herein. The subject treated with another agent effective in treatment or prophylaxis of the disease being treated may no longer be receiving treatment with an antibody disclosed herein.

[0338] Treatment with antibodies disclosed herein can be combined with other treatments effective against the disorder being treated. Combination treatments can be formulated together or administered separately. Some examples of treatments useful for combination therapies include a second anti-TTR antibody that binds an epitope different from that of 9D5 or 18C5, for example an antibody as disclosed in Table 3.

[0339] After treatment, the subject's condition can be evaluated to determine the progress or efficacy of such treatment. Such methods preferably test for changes in TTR amyloid levels or levels of non-native forms of TTR. For example, TTR amyloid levels may be evaluated to determine improvement relative to the subject's TTR amyloid levels under comparable circumstances prior to treatment. The subject's TTR amyloid levels can also be compared with control populations under comparable circumstances. The control populations can be similarly afflicted, untreated subjects or normal untreated subjects (among other control subjects).

Improvement relative to similarly afflicted, untreated subjects or levels approaching or reaching the levels in untreated normal subjects indicates a positive response to treatment.

[0340] TTR amyloid levels can be measured by a number of methods, including imaging techniques. Examples of suitable imaging techniques include PET scanning with radiolabeled TTR or fragments thereof, TTR antibodies or fragments thereof, Congo-red-based amyloid imaging agents, such as, *e.g.*, PIB (US 2011/0008255), amyloid-imaging peptide p31 (Biodistribution of amyloid-imaging peptide, p31, correlates with amyloid quantitation based on Congo red tissue staining, Wall *et al.*, Abstract No. 1573, 2011 ISNM Annual Meeting), and other PET labels. Levels of non-native forms of TTR can be measured, for example, by performing SDS-PAGE/Western blot or Meso Scale Discovery plate assays with the antibodies disclosed herein on plasma samples or biopsy samples from a subject and comparing to control samples, as described in the examples.

A. *Diagnostics and Monitoring Methods*

[0341] Also provided are methods of detecting an immune response against TTR in a patient suffering from or susceptible to diseases associated with TTR deposition or pathogenic forms of TTR (*e.g.*, monomeric, misfolded, aggregated, or fibril forms of TTR). The methods can be used to monitor a course of therapeutic and prophylactic treatment with the agents provided herein. The antibody profile following passive immunization typically shows an immediate peak in antibody concentration followed by an exponential decay. Without a further dose, the decay approaches pretreatment levels within a period of days to months depending on the half-life of the antibody administered. For example, the half-life of some human antibodies is of the order of 20 days.

[0342] In some methods, a baseline measurement of antibody to TTR in the subject is made before administration, a second measurement is made soon thereafter to determine the peak antibody level, and one or more further measurements are made at intervals to monitor decay of antibody levels. When the level of antibody has declined to baseline or a predetermined percentage of the peak less baseline (*e.g.*, 50%, 25% or 10%), administration of a further dose of antibody is administered. In some methods, peak or subsequent measured levels less background are compared with reference levels previously determined to constitute a beneficial prophylactic

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

[0343] Also provided are methods of detecting monomeric, misfolded, aggregated, or fibril forms of TTR in a subject, for example, by measuring TTR amyloid or pathogenic forms of TTR (*e.g.*, monomeric, misfolded, aggregated, or fibril forms of TTR) in a sample from a subject or by *in vivo* imaging of TTR in a subject. Such methods are useful to diagnose or confirm diagnosis of diseases associated with such pathogenic forms of TTR (*e.g.*, TTR amyloidosis), or susceptibility thereto. The methods can also be used on asymptomatic subjects. The presence of monomeric, misfolded, aggregated, or fibril forms of TTR indicates susceptibility to future symptomatic disease. The methods are also useful for monitoring disease progression and/or response to treatment in subjects who have been previously diagnosed with a TTR amyloidosis.

[0344] Biological samples obtained from a subject having, suspected of having, or at risk of having a TTR amyloidosis can be contacted with the antibodies disclosed herein to assess the presence of monomeric, misfolded, aggregated, or fibril forms of TTR. For example, levels of monomeric, misfolded, aggregated, or fibril forms of TTR in such subjects may be compared to those present in healthy subjects. Alternatively, levels of TTR amyloid or pathogenic forms of TTR (*e.g.*, monomeric, misfolded, aggregated, or fibril forms of TTR) in such subjects receiving treatment for the disease may be compared to those of subjects who have not been treated for a TTR amyloidosis. Some such tests involve a biopsy of tissue obtained from such subjects. ELISA assays can also be used, for example, for assessing levels of monomeric, misfolded, aggregated, or fibril forms of TTR in fluid samples. Some such ELISA assays involve anti-TTR antibodies that preferentially bind monomeric, misfolded, aggregated, or fibril forms of TTR relative to native tetrameric form of TTR.

[0345] Some such tests are sandwich immunoassays. Some such immunoassays employ the Meso Scale Discovery (MSD) electrochemiluminescence platform (Meso Scale Diagnostics, Rockville, MD.) Some such immunoassays use electrochemiluminescent labels on reporter antibodies, *e.g.*, MSD Assays (Meso Scale Diagnostics, Rockville, MD.) For example, the

reporter antibody can be labeled with a SULFO-TAG label ((Meso Scale Diagnostics, Rockville, MD). Plates useful in electrochemiluminescent assays may incorporate electrodes (e.g., MSD plates (Meso Scale Diagnostics, Rockville, MD). Plates useful in electrochemiluminescent assays may incorporate electrodes in the bottom of each well (e.g., MSD plates, (Meso Scale Diagnostics, Rockville, MD). Some assays employ a labeled capture antibody. For example, the labeled capture antibody can be 9D5 or 18C5 or a humanized, chimeric, or veneered variant thereof. Some assays employ a labeled reporter antibody. For example, the labeled reporter antibody can be 9D5 or 18C5 or a humanized, chimeric, or veneered variant thereof. The labeled reporter antibody can also be an antibody of Table 3, or a humanized, chimeric, or veneered variant thereof. The labeled reporter antibody can be an antibody that binds TTR with no conformational specificity. In an embodiment, the antibody that binds TTR with no conformational specificity can be 8C3 or 7G7 or a humanized, chimeric, or veneered variant thereof (See, e.g., WO 2016/120811). In an embodiment, the antibody that binds TTR with no conformational specificity can be a polyclonal antibody. In an embodiment, the polyclonal antibody is a polyclonal rabbit anti-human prealbumin (Cat. No. A000202-2, Dako, Agilent Technologies, Inc, Santa Clara, CA). In an embodiment, the polyclonal rabbit anti-TTR antibody is Sigma, Catalog No. HPA002550 (Sigma-Aldrich, St. Louis, MO),

[0346] Some assays detect all misfolded TTR in a sample (i.e., all misfolded forms of TTR including monomers and multimers). Other assays specifically detect monomeric misfolded TTR or multimeric misfolded TTR. Other assays detect all forms of TTR (misfolded forms and native tetrameric form). Some such assays employ a capture antibody that specifically binds to an epitope within residues 89-97 of TTR or an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and wherein detection of the reporter antibody that binds to the misfolded TTR, if any, indicates presence or absence of all the misfolded forms of TTR present in the sample. Such reporter antibodies can include 18C5, 9D5, 14G8, 5A1, 6C1, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof. Such reporter antibodies can include an antibody which binds within residues 89-97, 101-109, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or

115-127 of TTR. Such reporter antibodies can include 8C3 or 7G7 (see, e.g., WO 2016/120811). Such reporter antibodies can include a polyclonal rabbit anti-human prealbumin (Cat. No. A000202-2, Dako, Agilent Technologies, Inc, Santa Clara, CA) or a polyclonal rabbit anti-TTR antibody (Sigma, Catalog No. HPA002550, Sigma-Aldrich, St. Louis, MO). Some such assays detect misfolded forms of TTR in a biological sample from hereditary TTR amyloidosis patients carrying a mutation at position 89 within the 9D5 epitope of TTR. Exemplary mutations are E89K TTR and E89Q TTR. Some such assays employ a 9D5 capture antibody and a polyclonal anti-TTR reporter antibody or an 18C5 reporter antibody.

[0347] Some assays detect multimeric forms of misfolded TTR in a sample. Such assays can be configured to detect multimeric misfolded TTR preferentially or exclusively over monomeric misfolded TTR. Some such assays employ a capture antibody that specifically binds to an epitope within residues 89-97 or 101-109 of TTR and a reporter antibody that specifically binds to an epitope within residues 89-97 or 101-109 of TTR. Such a combination of capture and reporter antibodies can bind preferentially or exclusively to multimeric TTR over monomeric because the multiple copies of TTR provide multiple epitopes for antibody binding. Detection of reporter antibody binding to multimeric misfolded TTR, if any, indicates presence or absence of the multimeric misfolded TTR. In some such assays, the reporter antibody competes for binding TTR with the capture antibody and/or the reporter and capture antibody bind to the same or overlapping epitope of TTR. In some such assays the capture antibody binds a first misfolded TTR molecule in the multimeric misfolded TTR, and the reporter antibody binds a second misfolded TTR molecule in the multimeric misfolded TTR. Competition for binding between the capture and the reporter antibodies precludes or at least reduces (depending on whether competition is the result of overlapping epitopes or steric hindrance) simultaneous binding and detection of monomeric misfolded TTR. In some such assays, detection of the reporter antibody binding that binds to the second misfolded TTR molecule in the multimeric TTR indicates presence or absence of multimeric misfolded TTR.

[0348] The antibodies disclosed herein can be used in a method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample. A first portion of a biological sample can be assayed for all misfolded TTR in a sample (i.e., all misfolded forms of TTR including monomers and multimers) in a first assay

wherein monomeric misfolded and multimeric misfolded TTR are detected. The first assay can employ a capture antibody that specifically binds to an epitope within residues 89-97 or 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR. If misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex. Detection of the reporter antibody that binds to the misfolded TTR, if any, indicates presence or absence of the misfolded TTR in the sample. A second portion of a biological sample can be assayed for multimeric forms of misfolded TTR a biological sample in a second assay that detects multimeric misfolded TTR preferentially over monomeric misfolded TTR. The second assay can employ a capture antibody that specifically binds to an epitope within residues 89-97 or 101-109 of TTR and a reporter antibody that specifically binds to an epitope within residues 89-97 or 101-109 of TTR. If multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex. The capture and the reporter antibody can bind simultaneously preferentially or exclusively to the multimeric misfolded TTR, if any, to indicate presence or absence of the multimeric misfolded TTR. In some such assays, the reporter antibody competes for binding TTR with the capture antibody or binds to the same or overlapping epitope as the capture antibody. In some such assays the capture antibody binds a first misfolded TTR molecule in the multimeric misfolded TTR, and the reporter antibody binds a second misfolded TTR molecule in the multimeric misfolded TTR. Competition for binding between the capture and the reporter antibodies precludes or at least reduces (depending on whether competition is the result of overlapping epitopes or steric hindrance) simultaneous binding and detection of monomeric misfolded TTR. In some such assays, detection of the reporter antibody binding that binds to the second misfolded TTR molecule in the multimeric TTR indicates presence or absence of multimeric misfolded TTR. In some assays, a ratio of multimeric misfolded TTR to all misfolded TTR is calculated.

[0349] The antibodies disclosed herein can also be used in a method of determining a ratio of the level of all misfolded TTR to total TTR (misfolded forms and native tetrameric form) in a biological sample. A first portion of a biological sample can be assayed for all misfolded TTR in a sample (i.e., all misfolded forms of TTR including monomers and multimers), in a first assay wherein monomeric misfolded and multimeric misfolded TTR are detected. The first assay can employ a capture antibody that specifically binds to an epitope within residues 89-97 or 101-109

of TTR and a reporter antibody that specifically binds to a different epitope of TTR. If misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex. Detection of the reporter antibody binding to the misfolded TTR, if any, indicates presence or absence of the misfolded TTR in the sample. A second portion of a biological sample can be assayed for total TTR (misfolded forms and native tetrameric form) in a second assay wherein total TTR is detected. The second assay can employ a capture antibody that binds TTR with no conformational specificity and a reporter antibody that binds TTR with no conformational specificity. If TTR is present in the sample, the capture antibody and reporter antibody bind to the TTR forming a sandwich complex. Detection of the reporter antibody binding to the TTR, if any, indicates presence or absence of TTR present in the sample. A ratio of all misfolded TTR to total TTR (misfolded forms and native tetrameric form) can be calculated.

[0350] The *in vivo* imaging methods can work by administering a reagent, such as antibody that binds to monomeric, misfolded, aggregated, or fibril forms of TTR in the subject, and then detecting the reagent after it has bound. Such antibodies typically bind to an epitope within residues 89-97 or 101-109 of TTR. If desired, the clearing response can be avoided by using antibody fragments lacking a full length constant region, such as Fabs. In some methods, the same antibody can serve as both a treatment and diagnostic reagent.

[0351] Diagnostic reagents can be administered by intravenous injection into the body of the subject, or via other routes deemed reasonable. The dose of reagent should be within the same ranges as for treatment methods. Typically, the reagent is labeled, although in some methods, the primary reagent with affinity for monomeric, misfolded, aggregated, or fibril forms of TTR is unlabeled and a secondary labeling agent is used to bind to the primary reagent. The choice of label depends on the means of detection. For example, a fluorescent label is suitable for optical detection. Use of paramagnetic labels is suitable for tomographic detection without surgical intervention. Radioactive labels can also be detected using PET or SPECT.

[0352] Diagnosis is performed by comparing the number, size, and/or intensity of labeled loci to corresponding base line values. The base line values can represent the mean levels in a population of undiseased individuals. Base line values can also represent previous levels

determined in the same subject. For example, base line values can be determined in a subject before beginning treatment, and measured values thereafter compared with the base line values. A decrease in values relative to base line generally signals a positive response to treatment.

[0353] Monitoring of changes in amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, anti-TTR antibody binding or the like allows adjustment of a treatment regime in response to the treatment. Then a determination can be made whether to adjust treatment and if desired treatment can be adjusted in response to the monitoring. A significant change means that comparison of the value of a parameter after treatment relative to basement provides some evidence that treatment has or has not resulted in a beneficial effect. In some instances, a change of values of a parameter in a patient itself provides evidence that treatment has or has not resulted in a beneficial effect. In other instances, the change of values, if any, in a patient, is compared with the change of values, if any, in a representative control population of patients not undergoing treatment. A difference in response in a particular patient from the normal response in the control patient (e.g., mean plus variance of a standard deviation) can also provide evidence that a treatment regime is or is not achieving a beneficial effect in a patient. Changes in the above TTR parameters can also be combined with other change(s) in signs or symptoms such as side effects in determining whether and how to adjust treatment.

[0354] In some patients, monitoring indicates that the amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding is the same or greater than previously detected. In such patients, if there are no unacceptable side effects, the treatment regime can be continued as is or even increased in frequency of administration and/or dose if not already at the maximum recommended dose.

[0355] In some patients, monitoring indicates a detectable decline in amount of misfolded TTR, misfolded multimeric TTR, transthyretin deposits, anti-TTR antibody binding or the like but that amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding remains above normal. In such patients, if there are no unacceptable side effects, the treatment regime can be continued as is or even increased in frequency of administration and/or dose if not already at the maximum recommended dose. Alternatively, in some such patients, the treatment regime can be discontinued and replaced with treatment with

other agents, such as a TTR tetramer stabilizer, an antisense oligonucleotide based therapeutic, an RNA interference (RNAi) based therapeutic or doxycycline plus tauroursodeoxycholic acid.

[0356] If the monitoring indicates an amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, anti-TTR antibody binding or the like in a patient has already been reduced to at or near a normal level of amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or amount of anti-TTR antibody binding, the treatment regime can be adjusted from one of induction (i.e., that reduces the level of amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding) to one of maintenance (i.e., that maintains amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding at an approximately constant level). Such a regime can be effected by reducing the dose and or frequency of administering the treatment. Alternatively, in some such patients, the treatment regime can be discontinued and replaced with treatment with other agents, such as a TTR tetramer stabilizer, an antisense oligonucleotide based therapeutic, an RNA interference (RNAi) based therapeutic or doxycycline plus tauroursodeoxycholic acid.

[0357] In other patients, monitoring can indicate that the treatment regime is having some beneficial effect but a suboptimal effect. An optimal effect can be defined as a percentage reduction in amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding within the top half or quartile of the change in amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or amount of anti-TTR antibody binding) experienced by a representative sample of patients undergoing the treatment regime at a given time point after commencing therapy. A patient experiencing a smaller decline or a patient whose amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding remains constant or even increases but to a lesser extent than expected in the absence the treatment regime (e.g., as inferred from a control group of patients not administered the treatment regime) can be classified as experiencing a positive but suboptimal response. Such patients can optionally be subject to an adjustment of regime in which the dose and or frequency of administration of an agent is increased. Alternatively, or additionally if upward adjustment does not result in an improved response, in some such patients, the treatment regime can be discontinued and replaced with treatment with other agents, such as a TTR tetramer stabilizer, an

antisense oligonucleotide based therapeutic, an RNA interference (RNAi) based therapeutic or doxycycline plus tauroursodeoxycholic acid.

[0358] In some patients, amount of misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding may increase in similar or greater fashion to misfolded TTR, multimeric misfolded TTR, transthyretin deposits, or anti-TTR antibody binding in patients not receiving treatment. If such increases persist over a period of time, treatment can if desired be discontinued in favor of treatment with one or more other agents.

[0359] Diagnostic methods with antibodies disclosed herein can be performed in combination with a second anti-TTR antibody that binds an epitope different from that of 9D5 or 18C5, for example an antibody as disclosed in Table 3.

[0360] The assays disclosed herein can also be used to assess target engagement (pharmacodynamics effects) of unbound (free) misfolded-TTR in a biological sample from a subject by an antibody being used or tested for use in treatment. Such an antibody is referred to in the present assay as being a test antibody because it is being tested for its target engagement. In the present assay, the biological sample can be an aliquot of a larger sample, referred to as a collected sample, such that the assay can be run in a parallel manner of multiple aliquots of the collected sample. The test antibody competes with the capture antibody (or alternatively the reporter antibody) for binding to TTR. The test antibody can bind to the same epitope as the capture antibody (or the reporter antibody). The sandwich assay described above can be run in parallel for first and second aliquots of a collected sample, which are usually of the same volume. One aliquot is supplemented with the test antibody and both aliquots are supplemented with capture and reporter antibodies. In the aliquot without the test antibody, detection of the reporter antibody as part of a sandwich provides an indication of presence and amount of misfolded TTR in a sample. In the aliquot with the test antibody, detection of a reduced amount of reporter antibody as part of a sandwich relative to the aliquot without the test antibody provides an indication the test antibody is binding to misfolded TTR and thereby competing with either the capture or reporter antibody and reducing formation of a sandwich between the capture antibody, misfolded TTR and the reporter antibody. Such an assay can be performed on additional aliquots containing increasing amounts of the test antibody (as well as capture

antibody) further to characterize binding of the test antibody to misfolded TTR. The sample can be from a subject with a TTR amyloidosis. The sample can be from a subject with a hereditary TTR amyloidosis. The subject with a hereditary TTR amyloidosis may carry a mutation selected from the group consisting of V30M, Y114C, G47R, S50I, E61L, T49S, F33V, A45T, E89K, E89Q, and V122I. In some such assays, the biological sample is a plasma sample. In some such assays, the assay is performed with a 9D5 or 18C5 capture antibody and a polyclonal anti-TTR reporter antibody. Such an assay can be used to inform on target engagement in clinical trials of an antibody intended for therapeutic use as disclosed herein. In some such assays, the test antibody is 14G8, and the assay is performed with a 9D5 or 18C5 capture antibody and a polyclonal anti-TTR reporter antibody.

[0361] The assays disclosed herein can be used to measure pharmacodynamic effects of therapies targeting misfolded forms of TTR. In some such assays, target engagement of unbound (free) mis-TTR in a biological sample is measured after ex-vivo treatment (spiking) of a biological sample with a test antibody. The assays disclosed herein can also be used to measure efficacy of a test antibody in a patient. Biological samples are collected from a patient before and after treatment with a test antibody. In some such assays, target engagement of unbound (free) mis-TTR in a biological sample is measured before and after in vivo treatment of a patient with a test antibody. In some assays the target of the test antibody is an epitope within residues 89-97 of TTR. In some assays the target of the test antibody is an epitope within residues 101-109 of TTR.

[0362] The present methods also allow distinction of a transthyretin-mediated amyloidosis from a non-TTR amyloidosis, e.g. amyloid light-chain (AL) amyloidosis, also known as primary systemic amyloidosis.

IX. Kits

[0363] The invention further provides kits (*e.g.*, containers) comprising the 9D5 or 18C5 antibodies disclosed herein and related materials, such as instructions for use (*e.g.*, package insert). The instructions for use may contain, for example, instructions for administration of the antibodies and optionally one or more additional agents. The containers of antibodies may be unit doses, bulk packages (*e.g.*, multi-dose packages), or sub-unit doses.

[0364] Package insert refers to instructions customarily included in commercial packages of therapeutic products that contain information about the indications, usage, dosage, administration, contraindications and/or warnings concerning the use of such therapeutic products

[0365] Kits can also include a second container comprising a pharmaceutically-acceptable buffer, such as bacteriostatic water for injection (BWFI), phosphate-buffered saline, Ringer's solution and dextrose solution. It can also include other materials desirable from a commercial and user standpoint, including other buffers, diluents, filters, needles, and syringes.

X. Other Applications

[0366] The antibodies can be used for detecting monomeric, misfolded, aggregated, or fibril forms of transthyretin (TTR), or fragments thereof, in the context of clinical diagnosis or treatment or in research. For example, the antibodies can be used to detect the presence of monomeric, misfolded, aggregated, or fibril forms of TTR in a biological sample as an indication that the biological sample comprises TTR amyloid deposits. Binding of the antibodies to the biological sample can be compared to binding of the antibodies to a control sample. The control sample and the biological sample can comprise cells of the same tissue origin. Control samples and biological samples can be obtained from the same individual or different individuals and on the same occasion or on different occasions. If desired, multiple biological samples and multiple control samples are evaluated on multiple occasions to protect against random variation independent of the differences between the samples. A direct comparison can then be made between the biological sample(s) and the control sample(s) to determine whether antibody binding (*i.e.*, the presence of monomeric, misfolded, aggregated, or fibril forms of TTR) to the biological sample(s) is increased, decreased, or the same relative to antibody binding to the control sample(s). Increased binding of the antibody to the biological sample(s) relative to the control sample(s) indicates the presence of monomeric, misfolded, aggregated, or fibril forms of TTR in the biological sample(s). In some instances, the increased antibody binding is statistically significant. Optionally, antibody binding to the biological sample is at least 1.5-fold, 2-fold, 3-fold, 4-fold, 5-fold, 10-fold, 20-fold, or 100-fold higher than antibody binding to the control sample.

[0367] In addition, the antibodies can be used to detect the presence of monomeric, misfolded, aggregated, or fibril forms of TTR in a biological sample to monitor and evaluate the efficacy of a therapeutic agent being used to treat a patient diagnosed with a TTR amyloidosis. A biological sample from a patient diagnosed with a TTR amyloidosis is evaluated to establish a baseline for the binding of the antibodies to the sample (*i.e.*, a baseline for the presence of the monomeric, misfolded, aggregated, or fibril forms of TTR in the sample) before commencing therapy with the therapeutic agent. In some instances, multiple biological samples from the patient are evaluated on multiple occasions to establish both a baseline and measure of random variation independent of treatment. A therapeutic agent is then administered in a regime. The regime may include multiple administrations of the agent over a period of time. Optionally, binding of the antibodies (*i.e.*, presence of monomeric, misfolded, aggregated, or fibril forms of TTR) is evaluated on multiple occasions in multiple biological samples from the patient, both to establish a measure of random variation and to show a trend in response to immunotherapy. The various assessments of antibody binding to the biological samples are then compared. If only two assessments are made, a direct comparison can be made between the two assessments to determine whether antibody binding (*i.e.*, presence of monomeric, misfolded, aggregated, or fibril forms of TTR) has increased, decreased, or remained the same between the two assessments. If more than two measurements are made, the measurements can be analyzed as a time course starting before treatment with the therapeutic agent and proceeding through the course of therapy. In patients for whom antibody binding to biological samples has decreased (*i.e.*, the presence of monomeric, misfolded, aggregated, or fibril forms of TTR), it can be concluded that the therapeutic agent was effective in treating the TTR amyloidosis in the patient. The decrease in antibody binding can be statistically significant. Optionally, binding decreases by at least 1%, 2%, 3%, 4%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100%. Assessment of antibody binding can be made in conjunction with assessing other signs and symptoms of TTR amyloidosis.

[0368] The antibodies can also be used as research reagents for laboratory research in detecting monomeric, misfolded, aggregated, or fibril forms of TTR, or fragments thereof. In such uses, antibodies can be labeled with fluorescent molecules, spin-labeled molecules, enzymes, or radioisotopes, and can be provided in the form of kit with all the necessary reagents to perform the detection assay. The antibodies can also be used to purify monomeric, misfolded,

aggregated, or fibril forms of TTR, or binding partners of monomeric, misfolded, aggregated, or fibril forms of TTR, *e.g.*, by affinity chromatography.

[0369] The antibodies can also be used for inhibiting or reducing aggregation of TTR, inhibiting or reducing TTR fibril formation, reducing or clearing TTR deposits or TTR aggregates, or stabilizing non-toxic conformations of TTR in a biological sample. The biological sample can comprise, for example, blood, serum, plasma, or tissue (*e.g.*, tissue from the heart, peripheral nervous system, autonomic nervous system, kidneys, eyes, abdominal fat, or gastrointestinal tract). In some instances, TTR aggregation, TTR fibril formation, or TTR deposits are inhibited or reduced by at least 10%, 20%, 25%, 30%, 40%, 50%, or 75%, (*e.g.*, 10%-75% or 30%-70%). Assays for detecting fibril formation are described elsewhere herein. *See also* US 2014/0056904.

[0370] All patent filings, websites, other publications, accession numbers and the like cited above or below are incorporated by reference in their entirety for all purposes to the same extent as if each individual item were specifically and individually indicated to be so incorporated by reference. If different versions of a sequence are associated with an accession number at different times, the version associated with the accession number at the effective filing date of this application is meant. The effective filing date means the earlier of the actual filing date or filing date of a priority application referring to the accession number if applicable. Likewise if different versions of a publication, website or the like are published at different times, the version most recently published at the effective filing date of the application is meant unless otherwise indicated. Any feature, step, element, embodiment, or aspect of the invention can be used in combination with any other unless specifically indicated otherwise. Although the present invention has been described in some detail by way of illustration and example for purposes of clarity and understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims.

EXAMPLES

Example 1. Materials and reagent preparation

Table 4
Materials and assay reagents

Identity	Description	Lot/Batch/Cat No.	Supplier
Mouse 14G8	2.95 mg/mL in 1xPBS	PB-0334	Prothena
Goat anti-mouse IgG	IRDye 800CW conjugated, reconstituted with 0.5 mL H ₂ O	Cat. 925-32210	LI-COR
h14G8	49.4 mg/mL in formulation buffer (25mM Histidine, 230mM Trehalose, 0.02% Polysorbate 20, pH 6.5)	PNA PRX004 MSR01 DS02	Rentschler
Neutravidin	10 mg vial reconstituted in water then diluted to 1 mg/mL in PBS	Cat. 31000	ThermoFisher Scientific
Guanidine mis-TTR Standard	1 mg/mL wild-type TTR in 6M Guanidine HCl 1x PBS	PB-0216	Prothena
9D5 anti-misfolded-TTR-biotin mAb	1 mg/mL	PS021017D	Prothena
Rabbit anti-Hu TTR-SULFO-TAG polyclonal Ab (Dako)	1 mg/mL	PS022317A	Prothena
Human PreAlbumin (TTR) ELISA kit	Measures Total human TTR	Cat. AB108895	Abcam
SULFO-TAG-mouse-anti-misfolded TTR, Clone 18C5		PB-0386, Conjugate lot#01302017ST-JML	Prothena

Cat = catalog;; Hu = human; mAb = monoclonal antibody; MSD = Meso Scale Discovery; TTR = transthyretin; mis-TTR = misfolded TTR; ST SULFO-TAG; PBS Phosphate Buffered Saline pH 7.4.

[0371] Reagent Preparation

[0372] Biotinylation of 9D5: 1 mg/mL 9D5 in PBS was biotinylated following manufacturer's instructions with the exception of a 10M excess of NHS-biotin (Thermo-Fisher Cat. 21329) to antibody which was used instead of a 20M excess.

[0373] SULFO-TAG of Rabbit anti-TTR pAb: Antibody (Cat. No. A000202-2, Dako, Agilent Technologies, Inc, Santa Clara, CA) was diluted to 1 mg/mL in PBS then desalted using a Zeba spin column (ThermoFisher Scientific). 50 µL of cold H₂O was added to SULFO-TAG to

reconstitute and then the material was vortexed. 2.2 μ L of reconstituted SULFO-TAG was added to 50 μ L of diluted antibody, vortexed, incubated 2 hours at RT, and stored in the dark at 4°C.

[0374] Preparation of the Guanidine HCl misfolded-TTR Standard: Denatured human TTR was prepared by incubating 1 mg/mL purified recombinant human wild-type TTR in 1xPBS containing 6M guanidine hydrochloride for 24 hours at 4°C, then aliquoted and frozen at -70°C.

Example 2. ECL Method for Determination of Free Misfolded-TTR in Plasma

[0375] Free (unbound) misfolded-TTR, including monomer, was detected in human plasma using a quantitative ECL (Meso Scale Discovery; MSD) assay research method. A 96-well MSD plate was coated with 30 μ L per well of 4 μ g/mL neutravidin in PBS, incubated overnight at 4°C, and washed three times in TBS containing 0.05% Tween 20. Plates had non-specific binding sites blocked with 3% MSD Blocker A (MSD#: R93BA-4) in PBS for 1 hour at room temperature with shaking, then washed three times. 30 μ L of 1 μ g/mL biotinylated 9D5 in Assay Buffer (1% MSD Blocker A/PBS+0.05% Tween-20) was added to each well and incubated 1 hour at room temperature with shaking. The standard curve was prepared from a fresh aliquot of TTR in 6M guanidine HCl diluted into Diluent 2 (MSD#: R51BB-3). Standard Curve consisted of seven 4-fold dilutions starting at 200 ng/mL ending at 49 pg/mL. Patient or control plasma was diluted 1:5 in MSD Diluent 2. Standard or diluted plasma (30 μ L) were added to the plates in duplicate, incubated at room temperature with shaking for 2 hours then washed. 30 μ L of the polyclonal anti-TTR SULFO-TAG label ((Cat. No. A000202-2, Dako, Agilent Technologies, Inc, Santa Clara, CA) at 1 μ g/mL in assay buffer was added to each well, incubated 1 hour with shaking then washed. 150 μ L/well of 1X MSD Read Buffer T (MSD#: R92TC-1) was added to each well and read within 10 min on a MSD Sector Imager S600. The top and the bottom standard were anchor points and the curve had a quantitative range in neat plasma of 1 to 500 ng/mL equivalents based on the guanidine-HCl TTR standard.

Example 3. Bioanalysis of Free misfolded-TTR in TTR Amyloidosis Patient PLASMA

[0376] Individual and mean free misfolded-TTR levels (ng-eq/mL) in TTR Amyloidosis patient and normal plasma combined from two assay occasions are shown in Figure 1.

[0377] Results are shown in Figure 1. The first column (labeled h-ATTR asympto”) depicts results for asymptomatic patients with hereditary TTR amyloidosis. The second column (labeled

h-ATTR-taf”) depicts results for patients with hereditary TTR amyloidosis treated with tafamidis. The third column (labeled h-ATTR-no treatment”) depicts results for untreated patients with hereditary TTR amyloidosis. The fourth column (labeled “h-ATTR liver TX”) depicts results for patients with hereditary TTR amyloidosis with a liver transplant. The fifth column (labeled “WT-ATTR”) depicts results for patients with wild-type ATTR amyloidosis. The sixth column (labeled “Normal”) depicts results for healthy volunteers. Points are individual data and bars are mean and SD. * 0.01-0.05, ** 0.0005-0.0099, ***0.0001-0.005, and ****<0.0001 compared to Normal control (non-parametric Kruskal-Wallis test with Dunn’s multiplicity adjustment).

[0378] Abbreviations used in Figure 1:

asympt = asymptomatic; ATTR = amyloid transthyretin; eq = equivalents; GuHCL = guanidine hydrochloride; h = hereditary; mis = misfolded; std = standard; Tx = transplant; wt = wild type

[0379] Among hereditary TTR amyloidosis patients, there were significantly higher mean levels of misfolded-TTR in untreated patients, including showing asymptomatic carriers show misfolded-TTR before disease symptoms, and tafamidis-treated patients still show circulating misfolded-TTR, however in liver transplant patients levels were similar to normal controls with little or no detectable misfolded-TTR. Mean misfolded-TTR concentrations in the hereditary TTR amyloidosis patient samples with elevated levels ranged from 32 to 59 ng-eq/mL compared to 4 ng-eq/mL in normal controls. Hereditary TTR amyloidosis liver transplant patients produce normally folded TTR resulting in misfolded-TTR levels that were similar to normal, healthy subjects. The wild-type ATTR amyloidosis patient samples, with the exception of a single outlier, also had little or no detectable misfolded-TTR similar to normal plasma, suggesting that misfolding of TTR may occur locally within the affected tissue and misfolded-TTR does not readily circulate in this wild-type ATTR amyloidosis patient subset.

[0380] Among the noted outliers in the tafamidis-treated (1 low misfolded-TTR), and wild-type ATTR amyloidosis (1 high misfolded-TTR) patient samples, it is not clear if divergent values represent normal patient variation or were due to procedural error (i.e. inadvertent mis-labeling of samples). As a result, all reported values were included in data evaluations.

[0381] Additionally, the assay is able to detect misfolded-TTR in plasma from hereditary TTR amyloidosis patients carrying mutations at position 89 within the 9D5 epitope of TTR. Two mutations (E89K and E89Q) that fall within the 9D5 epitope (amino acid residues 89-97) did not affect 9D5 binding in the assay. While alanine mapping of the epitope showed this residue to be less important for antibody binding, it was unknown if substitutions that were not conserved for example acidic to basic amino acid (E89K) or charged to non- charged (E89Q) would impact antibody binding. The arrows in Figure 1 indicate these substitutions and the suitability of the assay for mutations at this amino acid. Table 5 shows all samples tested and the results in the 9D5-Dako polyclonal assay.

Table 5
samples tested and the results in the 9D5-Dako assay

Pro ID	Collaborator ID	Age	Sex	TTR Mutation	Treatment	misfolded-TTR (ng-eq/mL)
1	8120326	37	M	V30M	Liver TX	4
2	16091078	67	F	V30M	Untreated	24
4	3098983	44	M	V30M	Liver TX	4
5	98084122	44	F	Y114C	Tafamidis	26
6	1051830	45	F	V30M	Liver TX	3
7	12004496	44	M	V30M	Liver TX	3
8	16032804	74	M	V30M	Untreated	27
10	13097486	39	M	V30M	Tafamidis	26
11	11017266	30	F	V30M	Liver TX	3
12	14094510	72	M	V30M	Tafamidis	27
13	14053483	66	M	V30M	Tafamidis	29
14	96038112	53	F	V30M	Liver TX	2
15	11019596	48	M	V30M	Tafamidis	33
16	8099635	44	F	V30M	Liver TX	4
17	8110529	41	F	V30M	Tafamidis	45
18	16015447	52	M	G47R	Liver TX	4
19	95023663	54	F	V30M	Liver TX	3
20	4080271	38	M	Y114C	Tafamidis	29
21	16012192	34	M	S50I	Asymptom	19
22	84041739	54	F	V30M	Liver TX	3
23	98063581	38	F	S50I	Asymptom	24
24	16123223	24	M	V30M	Untreated	35
25	15085485	35	F	V30M	Tafamidis	30
26	5069417	37	F	V30M	Liver TX	6
27	8095365	48	F	V30M	Liver TX	4

Pro ID	Collaborator ID	Age	Sex	TTR Mutation	Treatment	misfolded-TTR (ng-eq/mL)
28	8099602	70	F	V30M	Tafamidis	37
29	16050297	27	F	G47R	Asymptom	48
30	16013388	68	F	V30M	Tafamidis	63
31	94045408	63	F	V30M	Liver TX	5
32	9105775	48	M	V30M	Liver TX	8
33	8127510	42	F	V30M	Asymptom	66
34	16129566	62	M	E61L	Tafamidis	4
35	9007376	34	F	V30M	Asymptom	88
36	98029314	41	F	V30M	Asymptom	77
37	15030924	26	M	V30M	Asymptom	80
38	15030913	27	F	V30M	Asymptom	90
39	17032391	39	M	T49S	Asymptom	15
40	12120567	64	M	V30M	Tafamidis	56
42	13063964	41	F	Y114C		
44	17057097	62	M	V30M		
45	17090197	72	M	V30M		
46	14044203	27	F	Y114C	Asymptom	
47	15048606	38	M	F33V		
SSA-1	15090038	81	M	wt-ATTR	Untreated	6
SSA-2	85017908	84	F	wt-ATTR	Untreated	6
SSA-3	16023646	78	M	wt-ATTR	Untreated	6
N1	n/a	38	M	Normal	n/a	7
N2	n/a	22	F	Normal	n/a	3
N3	n/a	24	F	Normal	n/a	4
N4	n/a	42	M	Normal	n/a	4
N5	n/a	29	F	Normal	n/a	3
N6	n/a	34	F	Normal	n/a	3
N7	n/a	51	M	Normal	n/a	3
N8	n/a	30	M	Normal	n/a	4
N9	n/a	28	M	Normal	n/a	6
1	03PA17002004001	n/a	M	A45T	Asymptom	50
2	557722	n/a	M	E89K	Asymptom	96
3	913320	n/a	F	E89Q	Untreated	32
4	03PA17000804	n/a	F	V122I	Untreated	18
5	03PA17002702	n/a	M	V30M	Untreated	76
6	03PA17001104	n/a	M	wt-ATTR	Untreated	96
7	03PA17001904	n/a	M	wt-ATTR	Untreated	7
8	03PA17000704	n/a	M	wt-ATTR	Untreated	7

Asymptom = asymptomatic; ATTR = amyloid transthyretin; eq = equivalents; mis = misfolded;

n/a = not applicable; wt = wild type

Example 4. Ex Vivo target engagement assay in selected TTR amyloidosis patient samples with Elevated misfolded-TTR Levels

[0382] To measure the ability of a potential mis-TTR therapeutic antibody (m14G8, mouse 14G8) to bind to plasma mis-TTR (target engagement), ATTR plasma (V30M) with high levels of mis-TTR were treated ex-vivo with increasing amount of m14G8. Binding of m14G8 to plasma mis-TTR (target) should decrease the amount of remaining unbound (free) mis-TTR since binding sites become occupied with m14G8, resulting in a concentration-dependent decrease in the MSD signal and evidence of target engagement by this mis-TTR mAb. Figure 9 depicts a diagram of such a target engagement assay.

[0383] Plasma samples from 12 patients with elevated levels of misfolded-TTR as measured in the free misfolded-TTR assay were selected for analysis in a target engagement experiment to show m14G8 (mouse 14G8) reduces levels of free misfolded-TTR when spiked into patient plasma. Since 9D5 (MSD plate ligand) and m14G8 bind to the same epitope and compete for free misfolded-TTR, the assay effectively quantitates free misfolded-TTR unbound to m14G8 (i.e. bound to 9D5), resulting in a reduction in ECL signal detection when competed off by m14G8 bound to misfolded-TTR. Neat TTR amyloidosis patient plasma was spiked with a range of m14G8 concentrations (0, 12, 40, 120, 400 or 1200 µg/mL) and incubated for 30 minutes at room temperature. Samples were diluted 1:5 and the assay and standard curves were run as described in Example 2.

[0384] Figure 2 shows the antibody competition curve for exemplary TTR amyloidosis patient plasma samples with elevated misfolded-TTR levels indicating free misfolded-TTR (%) levels in the presence of increasing concentrations of m14G8.

[0385] Abbreviations used in Figure 2:

EC50 = effective concentration 50% (free/unbound to m14G8); mis = misfolded

[0386] Mean (point) and SD (bar) of 12 individual h-ATTR plasma samples (each spiked sample value normalized to its pre-spike ECL signal at 0 nM m14G8 in plasma, i.e. 100% unbound misfolded-TTR). Line represents asymmetric sigmoidal nonlinear curve fit of data.

[0387] High background was compensated for by subtracting background signal at maximal competition. Since the bioassay only detects misfolded-TTR not bound to m14G8 (free misfolded-TTR), binding of misfolded-TTR by m14G8 results in decreased ECL signal with increased m14G8 in plasma. Accordingly, a m14G8 concentration-dependent reduction in free misfolded-TTR levels (%) was observed confirming m14G8 was able to target (bind) misfolded-TTR (including monomer) in h-ATTR patient plasma at an estimated EC₅₀ of 343 nM (~50 µg/mL). This assay is used to inform on target engagement in 14G8 trials.

Example 5: ECL Method for Determination of Free Misfolded-TTR in Plasma (9D5/18C5)

[0388] Method: Free (unbound) misfolded-TTR, including monomer, was detected in human plasma using a quantitative ECL (Meso Scale Discovery; MSD) assay research method. A 96-well MSD plate was coated with 30 µL per well of 4 µg/mL neutravidin in PBS, incubated overnight at 4°C, and washed three times in TBS containing 0.05% Tween 20. Plates had non-specific binding sites blocked with 3% MSD Blocker A in PBS for 1 hour at room temperature with shaking, then washed three times. 30 µL of 1 µg/mL 9D5-biotin in Assay Buffer (1% MSD Blocker A/PBS+0.05% Tween-20) was added to each well and incubated 1 hour at room temperature with shaking. The standard curve was prepared from a fresh aliquot of TTR in 6M guanidine HCl diluted into Assay Buffer. Standard Curve consisted of seven 5-fold dilutions starting at 1000 ng/mL ending at 64 pg/mL. Patient or control plasma was diluted 1:5 in Assay Buffer. Standard or diluted plasma (30 µL) were added to the plates in duplicate, incubated at room temperature with shaking for 1 hour then washed. 30 µL of the SULFO-TAG labeled 18C5 at 1 µg/mL in assay buffer was added to each well, incubated 1 hour with shaking then washed. 150 µL/well of 1X MSD Read Buffer T was added to each well and read within 10 minutes on a MSD Sector Imager S600. The top and the bottom standard were anchor points and the curve had a quantitative range in neat plasma of 1.6 to 1000 ng/mL equivalents based on the guanidine-HCl TTR standard.

[0389] Results are shown in Figure 3. The first column (labeled “h-ATTR asympto”) depicts results for asymptomatic patients with hereditary TTR amyloidosis. The second column (labeled “h-ATTR-taf”) depicts results for patients with hereditary TTR amyloidosis treated with tafamidis. The third column (labeled “h-ATTR-no treatment”) depicts results for untreated

patients with hereditary TTR amyloidosis. The fourth column (labeled “h-ATTR liver TX”) depicts results for patients with hereditary TTR amyloidosis with a liver transplant. The fifth column (labeled “Normal”) depicts results for normal patients.

[0390] Points are individual data and bars are mean and SD. * 0.01-0.05, ** 0.0005-0.0099, ***0.0001-0.005, ****<0.0001, compared to Normal control (non-parametric Kruskal-Wallis test with Dunn’s multiplicity adjustment).

[0391] Abbreviations used in Figure 3:

asym = asymptomatic; ATTR = amyloid transthyretin; eq = equivalents; GuHCl = guanidine hydrochloride; h = hereditary; mis = misfolded; std = standard; Tx = transplant; wt = wild type

Example 6. Preparation of the immunogen and Immunization of mice for 18C5

[0392] Both BALB/c and C57BL/6 female mice were injected with transthyretin engineered with a mutation at F87M and L110M referred to as transthyretin-double mutant (TTR-DM). Intraperitoneal injection of 50 µg/ mouse for three injections followed by 25 µg/mouse for 3 injections and followed by 10 µg/mouse for 4 injections of TTR-DM emulsified in RIBI adjuvant were injected weekly using 5 BALB/c, additionally 5 C57BL/6 mice were injected for 3 injections at 50 µg/mouse, 3 injections at 25 µg/mouse and 4 injections at 10 µg/mouse emulsified in RIBI adjuvant. Mice were titered against the TTR-DM, Native tetrameric TTR, and his-MCAM. Mice with the highest titers to TTR-DM and lowest titers to Native tetrameric TTR and his-MCAM (BALB/c #1 and 5 and C57BL/6 #4 and 5) were fused by a modification of Kohler and Milstein. Resultant hybridomas were screened against TTR-DM, native tetrameric TTR and his-MCAM. Hybridomas showing specificity to TTR-DM were cloned and further characterized. 18C5 was identified.

Example 7. Characterization of 18C5 by BIAcore

[0393] Analysis was performed using a Biacore T200 to compare the binding affinity of murine antibodies to recombinant human TTR denatured in 6M Guanidine Hydrochloride (Gu-hTTR), Cynomolgus TTR denatured in 6 M Guanidine Hydrochloride (Gu-cTTR) and native tetrameric human TTR. Anti-Mouse antibody was immobilized on sensor chip CM3 (GE Healthcare Life Sciences) via amine coupling, and murine antibodies (ligand) were captured to a level to ensure a

maximum binding of analyte of 50 RU (approximately 250RU of ligand binding). Various concentrations of Gu-TTR (ranging from 0.4 nM to 100 nM) were passed over the captured ligand at 50 μ L/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA, 50mM Gu-HCl) for 300s association time and 900s dissociation time. Regeneration of the chip surface was accomplished by 2 short injections of 10mM Glycine-HCl at pH 1.7. Concentrations of Gu-cTTR used ranged from 1-1000 nM, while concentrations of Human TTR tetramer ranged from 10 nM to 10,000 nM. Data was blank subtracted to both a sensor not containing ligand and 0 nM analyte concentration. Analysis was performed using a global 1:1 fit with Biacore Evaluation software (v3.0) with bulk refractive index set to zero RU. Binding data are shown in Table 6.

Table 6
Binding data of 18C5 toward human misfolded TTR and Cynomolgus misfolded TTR, and human TTR tetramer.

TTR	ka 1/Ms	kd 1/s	K_D nM
Human misfolded TTR	1.1X10 ⁵	6.2X10 ⁻⁴	5.9 nM
Cynomolgus misfolded TTR	1.0X10 ⁵	9.2X10 ⁻⁴	Minimal binding at highest concentration, hard to estimate KD
Human TTR tetramer	2.2X10 ³	2.2X10 ⁻⁴	Minimal binding at highest concentration, hard to estimate KD

Example 8. Characterization of chimeric 18C5 by BIAcore

[0394] Analysis was performed using a Biacore T200 to compare the binding affinity of murine and chimeric antibodies to recombinant human TTR denatured in 6M Guanidine Hydrochloride (Gu-hTTR). Anti-Human antibody was immobilized on flow cells 1 and 2, Anti-Mouse antibody was immobilized on flow cells 3 and 4 on sensor chip CM3 (GE Healthcare Life Sciences) via amine coupling, chimeric and murine 18C5 antibodies (ligand) were captured to a level to ensure a maximum binding of analyte of 50 RU (approximately 250RU of ligand binding). Various

concentrations of Gu-TTR (ranging from 0.4 nM to 100 nM) were passed over the captured ligand at 50 μ L/min in running buffer (HBS + 0.05% P-20, 1 mg/mL BSA, 50mM Gu-HCl) for 300s association time and 900s dissociation time. Regeneration of the chip surface was accomplished by 2 short injections of 3M Magnesium Chloride or 2 short injections of 10mM Glycine-HCl at pH 1.7. Data was blank subtracted to both a sensor not containing ligand and 0 nM analyte concentration. Analysis was performed using a global 1:1 fit with Biacore Evaluation software (v3.0) with bulk refractive index set to zero RU. Binding data are shown in Table 7.

[0395] A mature heavy chain variable region amino acid sequence of a chimeric 18C5 antibody is provided as SEQ ID NO:81, a mature light chain variable region amino acid sequence of a chimeric 18C5 antibody is provided as SEQ ID NO:87, a human heavy chain constant region amino acid sequence of SEQ ID NO: 17, and a human light chain constant region amino acid sequence of SEQ ID NO: 19.

[0396] Table 7. Binding data for murine and chimeric antibodies to recombinant human TTR denatured in 6M Guanidine Hydrochloride (Gu-hTTR).

TTR	k_a 1/Ms	k_d 1/s	K_D nM
Chimeric 18C5	1.3×10^5	1.6×10^{-4}	1.8 nM
Murine 18C5	9.9×10^4	2.1×10^{-4}	2.2 nM

Example 9. Epitope Mapping of 18C5

[0397] Initial mapping showed the epitope for 18C5 lies within 87-127 of SEQ ID NO: 26. Further mapping showed the epitope to lie between 101-109 of SEQ ID NO:26. The much lower affinity to misfolded Cynomolgus TTR suggest that amino acid 104 is important as this is the only amino acid substitution between human and Cynomolgus TTR.

Example 10. Sequence of 18C5

[0398] 18C5 hybridoma clone LA89 18C5. A1.A1 frozen cell pellet was used for mRNA extraction and purification. mRNA isolation & purification was performed using Oligotex direct mRNA mini kit (Qiagen, cat# 72022) protocol. Briefly, 9×10^6 hybridoma clone cells were lysed and homogenized in the presence of highly denaturing guanidine-isothiocyanate buffer, which inactivates RNases. Oligotex suspension was added to the lysis mix, hybridization was allowed to take place between the oligo dT30 of the oligotex particles and the poly-A tail of the mRNA. Contaminations were then washed and poly-A⁺ RNA was eluted. mRNA was reverse transcribed to cDNA using Marathon cDNA amplification kit (Clontech, cat# 634913). An adaptor was ligated to the 5' terminus of the cDNA. 5' RACE method was used to amplify V regions. 5' V region consensus primers and constant region specific anchor primers were used for PCR. Amplified V regions were cloned into pTOPO cloning vector and transformed into Top10 E. coli. 15-20 individual colonies were grown up and purified plasmid was sequenced. A clone sequence was considered a genuine V region sequence if it met following criteria

No stop codon between Met and C region

The sequence contains key features of antibody V regions

The sequence contains definable CDRs.

Minimum three independent clones with matching ORF

[0399] Variable region sequences determined were cloned into expression vectors and transfected into CHO cells. Purified chimeric antibody was characterized for binding using murine 18C5 as control antibody.

[0400] The mature heavy chain variable amino acid sequence of 18C5 is provided as SEQ ID NO:81, and the mature light chain variable amino acid sequence of 18C5 is provided as SEQ ID NO:87. The Kabat/Chothia Composite heavy chain CDR-H1, CDR-H2, and CDR-H3 amino acid sequences are provided as SEQ ID NOs 5, 7, and 9, respectively. The Kabat/Chothia Composite light chain CDR-L1, CDR-L2, and CDR-L3 amino acid sequences are provided as SEQ ID NOs 11, 13, and 15, respectively.

Example 11. Specificity of 18C5 Demonstrated by Western Blot Analysis

[0401] To demonstrate the conformational specificity of 18C5 toward non-native (denatured) TTR, a Western blot analysis was performed as follows:

Procedure:

[0402] SDS-polyacrylamide gels

[0403] Native TTR: A 1.0, 0.5, and 0.1 µg sample of recombinant human TTR in LDS sample buffer (Life Technologies) was run on a 10% NuPAGE bis-tris gel (MES buffer; 90 V, 105 min) and transferred to nitrocellulose membranes for Western blot analysis.

[0404] Denatured TTR: Recombinant human TTR was prepared as described above for native TTR except the LDS sample buffer contained reducing agent and the samples were denatured by boiling prior to SDS-PAGE.

[0405] Western blot analysis

[0406] SDS-PAGE gels were blotted onto nitrocellulose membranes (iBlot, Life Technologies), treated with blocking buffer (LI-COR, Lincoln, NE) and incubated in 1.0-µg /mL primary antibody, washed with 1x TBS and placed in 1:20,000 dilution of IRDye 800CW-conjugated goat-anti-mouse or anti-rabbit secondary antibody (LI-COR, Lincoln, NE), then imaged on an Odyssey CLx infrared imager (LI-COR, Lincoln, NE).

[0407] Results and Conclusions:

[0408] Western blot of native vs denatured recombinant TTR (Figure 4) showed that 18C5 had very weak reactivity toward native TTR species (Lanes 1-3), but very strong reactivity toward denatured TTR monomer (~15kDa) with minor reactivity toward denatured dimer (~30kDa) (Lanes 5-7). Lane 4 shows molecular weight markers.

[0409] In contrast, a commercial TTR antibody (Sigma, Catalog No. HPA002550) that is not conformationally specific did not distinguish between native versus denatured TTR and showed very strong reactivity toward monomeric as well as dimeric native and denatured TTR (Figure 5). Lanes 1-3 show results for Native TTR; Lane 4 shows molecular weight markers, and Lanes 5-7 show results for Denatured TTR.

Example 12 18C5 use in a potential diagnostic for TTR amyloidosis

[0410] A sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform was used to detect total misfolded TTR (Total misTTR) in patient plasma samples. Samples were from normal patients and patients with transthyretin-mediated amyloidosis (ATTR). Patients with transthyretin-mediated amyloidosis (ATTR) had the following TTR mutations and treatments: ATTR (V30M familial amyloid polyneuropathy (FAP)) with Liver Transplant, ATTR (V30M familial amyloid polyneuropathy (FAP)) No Treatment, ATTR (V30M familial amyloid polyneuropathy (FAP)) with Tafamidis, ATTR (Y114C familial amyloid polyneuropathy (FAP)) with Tafamidis, and ATTR (S50I) No Treatment.

[0411] Briefly, 96-well MSD standard plate was first coated with NeutrAvidin Protein (Thermo Fisher Scientific, Waltham, MA), followed by blocking with 3% Blocker A in PBS (MSD, Rockville, MD). Biotinylated 18C5 was then added to each well at 0.5 µg/mL to capture misfolded TTR. Plasma samples were diluted 5-fold in 1% Blocker A/PBS before transferred to the MSD plate, along with guanidine denatured TTR as reference standard. After 1 -hour incubation, misfolded TTR bound to the wells was detected with SULFO-TAG™-labeled Polyclonal Rabbit Anti-Human TTR (Agilent Technologies, Santa Clara, CA). Chemiluminescence signals proportional to the amount of misfolded TTR were generated by addition of 1X MSD Read Buffer and captured on a MESO SECTOR S 600 plate reader.

[0412] Results are shown in Figure 6. The first column (labeled “ATTR”) depicts results for patients with transthyretin-mediated amyloidosis (ATTR) with either no treatment or with tafamidis. The second column (labeled “ATTR (Liver TX)”) depicts results for patients with transthyretin-mediated amyloidosis (ATTR) with a liver transplant. The third column (labeled “Normal”) depicts results for normal patients. 18C5 detected elevated misfolded TTR in all but one of the transthyretin-mediated amyloidosis (ATTR) patients that had not undergone a liver transplant. Transthyretin-mediated amyloidosis (ATTR) patients undergoing a liver transplant and normal patients showed low levels of misfolded TTR with one exception in the Liver transplant group. It should be noted that the levels are ng/ml equivalents based off a guanidine

denatured TTR standard curve. The two patients with results that were anomalous were collected on the same day and is possible the samples were switched when aliquoted.

Example 13. 18C5-18C5 for determination of multimeric misfolded TTR

[0413] A sandwich immunoassay employing the Meso Scale Discovery (MSD) electrochemiluminescence platform was used to detect total multimeric misfolded TTR (Total Multimeric misTTR) in patient plasma samples. Samples were from normal patients and patients with transthyretin-mediated amyloidosis (ATTR). Patients with transthyretin-mediated amyloidosis (ATTR) had the following TTR mutations and treatments: ATTR (V30M familial amyloid polyneuropathy (FAP)) with Liver Transplant, ATTR (V30M familial amyloid polyneuropathy (FAP)) No Treatment, ATTR (V30M familial amyloid polyneuropathy (FAP)) with Tafamidis, ATTR (Y114C familial amyloid polyneuropathy (FAP)) with Tafamidis, and ATTR (S50I) No Treatment.

[0414] MSD plates were coated overnight with 4µg/mL NeutrAvidin. Plates were blocked for 1 hour with 3% MSD Blocker A, then washed 3x with Tris Buffered Saline with 0.1% Tween-20 (TBS-T). 1µg/mL biotinylated 18C5 was added for 1 hour, followed by 3x wash with TBS-T. Samples were diluted 5-fold in sample diluent (PBS + 0.1% BSA + 0.05% Triton X-100) and then were added to the plate in duplicate. A standard curve of TTR-DM was used ranging in concentration from 64pg/mL to 1µg/mL, with a 0µg/mL blank. Plates were washed 3x with TBS-T, followed by an addition of 1µg/mL 18C5 labeled with MSD Sulfo-tag, in sample diluent, and incubated for 1 hour. Finally, plates were washed 3x with TBS-T, and 150uL of MSD Read Buffer T was added, and plates were read on the MESO SECTOR S 600 plate reader. Samples were analyzed using MSD Discovery Workbench 4.0.

[0415] Results are shown in Figure 7. The first column (labeled “ATTR”) depicts results for patients with transthyretin-mediated amyloidosis (ATTR) with either no treatment or with tafamidis. The second column (labeled “ATTR (Liver TX)”) depicts results for patients with transthyretin-mediated amyloidosis (ATTR) with a liver transplant. The third column (labeled “Normal”) depicts results for normal patients. While not as many of the samples were positive for multimeric TTR, all positives were in the TTR patient samples, there was a statistical difference using a Kruskal Wallis test with Dunn correction of $P=0.04$ with patient samples to

patients with liver transplant and $P=0.004$ between patients and normal controls. There was no significance between normal controls and patients treated with liver transplant.

Example 14. 9D5 detects elevated levels of mis-TTR (misfolded TTR monomers and oligomers) in plasma from hereditary ATTR patients

[0416] Collection of ATTR and normal plasma

Blood from ATTR patients with a positive diagnosis of hereditary (h-ATTR) and wildtype ATTR (WT-ATTR) were collected in 7ml Vacutainer K2-EDTA tubes and centrifuged to remove cellular debris. The plasma fractions were aliquoted into 1.5ml LoBind Eppendorf tubes and immediately frozen. Plasma samples from healthy normal volunteers were collected in the same fashion. All samples were used immediately after thawing and not refrozen. Samples are as described in Table 5.

[0417] Analysis of ATTR plasma by Western blot

Plasma samples were diluted 10-fold into lithium dodecyl sulfate sample buffer (Life Technologies), loaded (12 μ L) on a 10% NuPAGE bis-tris gel, electrophoresed at 90V for 105min., transferred to a nitrocellulose membrane and probed with 1.0 μ g/mL mis-TTR 9D5 followed by 1:20,000 dilution of IRDye 800CW-conjugated goat-anti-mouse secondary antibody (LICOR). The blot was then rinsed and imaged on an Odyssey CLx infrared imager (LI-COR). Results are shown in Figure 8.

[0418] Legend of Figure 8:

Primary mAb: 1 μ g/ml 9D5; M, molecular weight markers (BioRad); solid black star, non-liver transplanted TTR-V30M patients; hatched star, (Patients 5, 20) TTR-T114C; open star, (Patients 21, 23) TTR-S50I; no star, liver transplantation; 1N-5N, normal (correspond to Pro IDs N1-N5 in Table 5).

[0419] The conformation-specific mis-TTR antibody 9D5 detects elevated levels of mis-TTR species (monomers and oligomers) in plasma derived from hereditary ATTR patients. In contrast, plasma from hereditary ATTR patients that had undergone liver transplantation therapy had barely detectable levels of mis-TTR similar to those in plasma from normal individuals.

Example 15. Elevated levels of mis-TTR in plasma from hereditary ATTR Patients

[0420] Collection of ATTR and normal plasma

[0421] Blood from ATTR patients with a positive diagnosis of hereditary (h-ATTR) and wildtype ATTR (WT-ATTR) were collected in 7ml Vacutainer K2-EDTA tubes and centrifuged to remove cellular debris. The plasma fractions were aliquoted into 1.5ml LoBind Eppendorf tubes and immediately frozen. Plasma samples from healthy normal volunteers were collected in the same fashion. All samples were used immediately after thawing and not refrozen. Samples are as described in Table 5.

[0422] Total mis-TTR in human plasma was detected using a Meso Scale Discovery (MSD) qualitative electrochemiluminescence assay. MSD plates were coated overnight with 4 µg/mL NeutrAvidin followed by 1 µg/mL biotinylated mis-TTR 9D5. Plasma samples were diluted 5-fold in sample diluent (PBS + 0.1% BSA + 0.05% Tween-20) prior to adding to the plate. Plates were washed with TBS-T, followed by the addition of 1 µg/mL anti-TTR polyclonal antibody (Dako) labeled with MSD Sulfo-tag. Plates were washed with TBS-T and read on an MSD Sector S 600 after addition of 150 µL/well of diluted MSD Read Buffer T. Samples were analyzed using MSD Discovery Workbench 4.0.

[0423] Results are shown in Figure 10.

[0424] Legend of Figure 10:

h-ATTR, hereditary ATTR; Liver TX, liver transplant. Limits of quantification (BLQ) of 1.0 ng/ml; Bars represent group means and SD; p values, Mann-Whitney test.

[0425] mis-TTR levels in plasma from hereditary ATTR patients are significantly elevated relative to normal controls. Elevated levels of mis-TTR were also observed in asymptomatic individuals positively genotyped for TTR mutations. Normal, low (<10 ng/ml to BLQ) levels of mis-TTR were observed in plasma from hereditary ATTR patients that had undergone liver transplantation treatment.

Example 7. Design of Humanized 18C5 Antibodies

[0426] The starting point or donor antibody for humanization was the mouse antibody 18C5. The heavy chain variable amino acid sequence of mature m18C5 is provided as SEQ ID NO: 81. The light chain variable amino acid sequence of mature m18C5 is provided as SEQ ID NO:87. The heavy chain Kabat/Chothia Composite CDR1, CDR2, and CDR3 amino acid sequences are provided as SEQ ID NOs:5, 7, and 9, respectively. The light chain Kabat CDR1, CDR2, and CDR3 amino acid sequences are provided as SEQ ID NOs:11, 13, and 15 respectively. Kabat numbering is used throughout.

[0427] Alignment of the variable region sequences of 18C5 with the consensus sequences of antibody variable regions from Kabat, *et al.* indicates that the heavy chain variable region (VH) of 18C5 belongs to mouse VH subgroup 3b, which corresponds to human VH subgroup 3. The kappa light chain variable region (VL) of 18C5 belongs to mouse Vk subgroup 2, which corresponds to human Vk subgroup 2. [Kabat E.A., et al, (1991) Sequences of Proteins of Immunological Interest, Fifth Edition. NIH Publication No. 91-3242.].

[0428] The residues at the interface between the Vk and Vh domains are the ones commonly found, except that Ala is at position 37 in heavy chain, whereas typically Val or Ile is at this position. Leu at position 95 in Vh is typically Asp, Gly or Ser. These positions are candidates for back mutations. For the Vk chain Glu 34 is typically Ala, His, Asn or Ser, and these positions are candidates for back mutations.

[0429] The CDRs of 18C5 VH and VL were identified using Martin's sequence-based CDR-identification rules. The CDRs were then assigned to the Chothia canonical classes using the summary of key residues presented in Table 3.5 of Martin (Martin ACR. (2010). In: Kontermann R and Dübel S (eds). *Antibody Engineering*. Heidelberg, Germany: Springer International Publishing AG.):

CDR-H1 consists of 10 amino acids and is similar to Chothia canonical class 1.
CDR-H2 consists of 17 amino acids and is similar to Chothia canonical class 3.
CDR-H3 consists of 4 amino acids; there are no classes for CDR-H3.

CDR-L1 consists of 16 amino acids and is similar to Chothia canonical class 4.
CDR-L2 consists of 7 amino acids and is of Chothia canonical class 1.
CDR-L3 consists of 9 amino acids and is similar to Chothia canonical class 1.

[0430] A search was made over the protein sequences in the PDB database [Deshpande et al, 2005, Nucleic Acids Research 33:D233-D237] to find structures, which would provide a rough structural model of 18C5. The crystal structure of murine anti-pyroglutamate-Abeta antibody Fab c#17 (PDB code 5MYK) [Piechotta, A. *et al.* ((2017) J. Biol. Chem. 292: 12713–12724) was used for both Vh and Vk structure since it had good resolution (1.6Å°) and overall sequence similarity to 18C5 Vh and Vk, retaining the same canonical structures for the loops. Bioluminate software was used to model a rough structure of 18C5. This software is licensed from Schrodinger Inc.

[0431] The frameworks of 18C5 VH and VL share a high degree of sequence similarity with the corresponding regions of humanized Crenezumab Fab (CreneFab) PDB: 5VZY, designed by Ultsch M, et al. ((2016) Sci Rep.6:39374) The variable domains of 18C5 and CreneFab also share identical lengths for the CDR-H1, H2, L1, L2, and L3 loops. The framework regions of CreneFab VH (5VZY-VH) and VL (5VZY-VL) were chosen as the acceptor sequences for the CDRs of 18C5. Bioluminate software was used to model the structure. This software is licensed from Schrodinger Inc.

[0432] Heavy and light chain variant sequences resulting from antibody humanization process were further aligned to human germ line sequences using IMGT Domain GapAlign tool to assess the humanness of the heavy and light chain as outlined by WHO INN committee guidelines. (WHO-INN: International nonproprietary names (INN) for biological and biotechnological substances (a review) (Internet) 2014. Available from: <http://www.who.int/medicines/services/inn/BioRev2014.pdf>) Residues were changed to align with corresponding human germ line sequence, where possible, to enhance humanness. For humanized VL_v2 variant, a Q45R mutation was introduced to render the sequence more similar to human germline gene IGKV2-30*02 (GenBank acc. No. CAA77315; SEQ ID NO:90). The amino acid sequences consisting of CreneFab frameworks and 18C5 CDRs are designated hu18C5-VH_v1 and hu18C5-VL_v1.

[0433] Additional versions of hu18C5-VH and hu18C5-VL were designed to enable assessment of various framework residues for their contributions to antigen binding and immunogenicity.

The positions considered for mutation include those that:

- define the canonical CDR conformations (summarized in Martin 2010),
- are within the Vernier zone (Foote J and Winter G. (1992). *J Mol Biol.* 224(2):487-99),
- localize to the VH/VL domain interface (summarized in Léger OJP and Saldanha J. (2000) Preparation of recombinant antibodies from immune rodent spleens and the design of their humanization by CDR grafting. In: Shepherd P and Dean C (eds). *Monoclonal Antibodies: a Practical Approach*. Oxford, UK: Oxford University Press),
- are susceptible to post-translational modifications, such as glycosylation or pyroglutamination,
- are occupied by residues that are predicted to clash with CDRs, according to the model of 18C5 CDRs grafted onto Crenezumab Fab frameworks, or
- are occupied by residues that are rare among sequenced human antibodies, where either the parental mouse 18C5 residue or some other residue is much more prevalent.

[0434] 2 humanized heavy chain variable region variants and 2 humanized light chain variable region variants were constructed containing different permutations of substitutions: hu18C5-VH_v1 and hu18C5-VH_v2, (SEQ ID NOs: 85-86, respectively) and hu18C5-VL_v1 and hu18C5-VL_v2_v6 (SEQ ID NOs: 91-92, respectively). (Tables 8 and 9). The exemplary humanized Vk and Vh designs, with backmutations and other mutations based on selected human frameworks, are shown in Tables 8 and 9, respectively. The bolded areas in Tables 8 and 9 indicate the CDRs as defined by Kabat/Chothia Composite. A “–” indicates no amino acid at the indicated position. SEQ ID NOs: 86 and 92 contain backmutations and other mutations as shown in Table 10. The amino acids at positions in hu18C5-VH_v1 and hu18C5-VH_v2 are listed in Table 11. The amino acids at positions in hu18C5-VL_v1 and hu18C5-VL_v2 are listed in Table 12. The percentage humanness for humanized VH chains hu18C5-VH_v1 and hu18C5-

VH_v2 (SEQ ID NOs: 85-86, respectively) with respect to the most similar human germline gene IGHV3-48*01, and for humanized VL chains hu18C5-VL_v1 and hu18C5-VL_v2 (SEQ ID NOs: 91-92, respectively) with respect to the most similar human germline gene IGKV2-30*02, is shown in Table 13.

Table 8: Humanized 18C5 VL Regions

<u>Linear residue #</u>	<u>Kabat residue #</u>	FR or CDR	<u>Murine 18C5 VL (SEQ ID NO:87)</u>	<u>Acceptor 5VZY-VL_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO: 89)</u>	<u>hu18C5-VL_v1 (SEQ ID NO:91)</u>	<u>hu18C5-VL_v2 (SEQ ID NO:92)</u>
1	1	Fr1	D	D	D	D
2	2	Fr1	V	I	I	V
3	3	Fr1	L	V	V	V
4	4	Fr1	M	M	M	M
5	5	Fr1	T	T	T	T
6	6	Fr1	Q	Q	Q	Q
7	7	Fr1	T	S	S	S
8	8	Fr1	P	P	P	P
9	9	Fr1	L	L	L	L
10	10	Fr1	S	S	S	S
11	11	Fr1	L	L	L	L
12	12	Fr1	P	P	P	P
13	13	Fr1	V	V	V	V
14	14	Fr1	S	T	T	T
15	15	Fr1	L	P	P	P
16	16	Fr1	G	G	G	G
17	17	Fr1	D	E	E	E
18	18	Fr1	Q	P	P	P
19	19	Fr1	A	A	A	A
20	20	Fr1	S	S	S	S
21	21	Fr1	I	I	I	I
22	22	Fr1	S	S	S	S
23	23	Fr1	C	C	C	C
24	24	CDR-L1	R	R	R	R
25	25	CDR-L1	S	S	S	S
26	26	CDR-L1	S	S	S	S

27	27	CDR-L1	Q	Q	Q	Q
28	27A	CDR-L1	S	S	S	S
29	27B	CDR-L1	I	L	I	I
30	27C	CDR-L1	V	V	V	V
31	27D	CDR-L1	D	Y	D	D
32	27E	CDR-L1	S	S	S	S
33	27F	CDR-L1		—	—	—
34	28	CDR-L1	N	N	N	N
35	29	CDR-L1	G	G	G	G
36	30	CDR-L1	N	D	N	N
37	31	CDR-L1	T	T	T	T
38	32	CDR-L1	Y	Y	Y	Y
39	33	CDR-L1	L	L	L	L
40	34	CDR-L1	E	H	E	E
41	35	Fr2	W	W	W	W
42	36	Fr2	Y	Y	Y	Y
43	37	Fr2	L	L	L	L
44	38	Fr2	Q	Q	Q	Q
45	39	Fr2	K	K	K	K
46	40	Fr2	P	P	P	P
47	41	Fr2	G	G	G	G
48	42	Fr2	Q	Q	Q	Q
49	43	Fr2	S	S	S	S
50	44	Fr2	P	P	P	P
51	45	Fr2	K	Q	Q	R
52	46	Fr2	L	L	L	L
53	47	Fr2	L	L	L	L
54	48	Fr2	I	I	I	I
55	49	Fr2	Y	Y	Y	Y
56	50	CDR-L2	K	K	K	K
57	51	CDR-L2	V	V	V	V
58	52	CDR-L2	S	S	S	S
59	53	CDR-L2	N	N	N	N
60	54	CDR-L2	R	R	R	R
61	55	CDR-L2	F	F	F	F
62	56	CDR-L2	S	S	S	S
63	57	Fr3	G	G	G	G
64	58	Fr3	V	V	V	V
65	59	Fr3	P	P	P	P

66	60	Fr3	D	D	D	D
67	61	Fr3	R	R	R	R
68	62	Fr3	F	F	F	F
69	63	Fr3	S	S	S	S
70	64	Fr3	G	G	G	G
71	65	Fr3	S	S	S	S
72	66	Fr3	G	G	G	G
73	67	Fr3	S	S	S	S
74	68	Fr3	G	G	G	G
75	69	Fr3	T	T	T	T
76	70	Fr3	D	D	D	D
77	71	Fr3	F	F	F	F
78	72	Fr3	T	T	T	T
79	73	Fr3	L	L	L	L
80	74	Fr3	K	K	K	K
81	75	Fr3	I	I	I	I
82	76	Fr3	S	S	S	S
83	77	Fr3	R	R	R	R
84	78	Fr3	V	V	V	V
85	79	Fr3	E	E	E	E
86	80	Fr3	A	A	A	A
87	81	Fr3	E	E	E	E
88	82	Fr3	D	D	D	D
89	83	Fr3	L	V	V	V
90	84	Fr3	G	G	G	G
91	85	Fr3	I	V	V	V
92	86	Fr3	Y	Y	Y	Y
93	87	Fr3	Y	Y	Y	Y
94	88	Fr3	C	C	C	C
95	89	CDR-L3	F	S	F	F
96	90	CDR-L3	Q	Q	Q	Q
97	91	CDR-L3	G	S	G	G
98	92	CDR-L3	S	T	S	S
99	93	CDR-L3	H	H	H	H
100	94	CDR-L3	V	V	V	V
101	95	CDR-L3	P	P	P	P
102	95A	CDR-L3	—	—	—	—
103	95B	CDR-L3	—	—	—	—
104	95C	CDR-L3	—	—	—	—

105	95D	CDR-L3	_	_	_	_
106	95E	CDR-L3	_	_	_	_
107	95F	CDR-L3	_	_	_	_
108	96	CDR-L3	L	W	L	L
109	97	CDR-L3	T	T	T	T
110	98	Fr4	F	F	F	F
111	99	Fr4	G	G	G	G
112	100	Fr4	A	Q	Q	Q
113	101	Fr4	G	G	G	G
114	102	Fr4	T	T	T	T
115	103	Fr4	K	K	K	K
116	104	Fr4	L	V	V	V
117	105	Fr4	E	E	E	E
118	106	Fr4	L	I	I	I
119	106A	Fr4	_	_	_	_
120	107	Fr4	K	K	K	K

Table 9: Humanized 18C5 VH Regions

Linear residue #	Kabat residue #	FR or CDR	Murine 18C5 VH (SEQ ID NO: 81)	Acceptor 5VZY-VH_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO:83)	hu18C5-VH_v1 (SEQ ID NO:85)	hu18C5-VH_v2 (SEQ ID NO:86)
1	1	Fr1	E	E	E	E
2	2	Fr1	V	V	V	V
3	3	Fr1	K	Q	Q	Q
4	4	Fr1	L	L	L	L
5	5	Fr1	L	V	V	V
6	6	Fr1	E	E	E	E
7	7	Fr1	S	S	S	S
8	8	Fr1	G	G	G	G
9	9	Fr1	G	G	G	G
10	10	Fr1	G	G	G	G
11	11	Fr1	L	L	L	L
12	12	Fr1	V	V	V	V
13	13	Fr1	Q	Q	Q	Q
14	14	Fr1	P	P	P	P
15	15	Fr1	G	G	G	G
16	16	Fr1	G	G	G	G
17	17	Fr1	S	S	S	S
18	18	Fr1	L	L	L	L
19	19	Fr1	N	R	R	R
20	20	Fr1	L	L	L	L
21	21	Fr1	S	S	S	S
22	22	Fr1	C	C	C	C
23	23	Fr1	V	A	A	A
24	24	Fr1	A	A	A	A
25	25	Fr1	S	S	S	S
26	26	CDR-H1	G	G	G	G

27	27	CDR-H1	F	F	F	F
28	28	CDR-H1	D	T	D	D
29	29	CDR-H1	F	F	F	F
30	30	CDR-H1	S	S	S	S
31	31	CDR-H1	R	S	R	R
32	32	CDR-H1	F	Y	F	F
33	33	CDR-H1	W	G	W	W
34	34	CDR-H1	M	M	M	M
35	35	CDR-H1	S	S	S	S
36	35A	CDR-H1	—	—	—	—
37	35B	CDR-H1	—	—	—	—
38	36	Fr2	W	W	W	W
39	37	Fr2	A	V	V	A
40	38	Fr2	R	R	R	R
41	39	Fr2	Q	Q	Q	Q
42	40	Fr2	A	A	A	A
43	41	Fr2	P	P	P	P
44	42	Fr2	G	G	G	G
45	43	Fr2	R	K	K	K
46	44	Fr2	G	G	G	G
47	45	Fr2	Q	L	L	Q
48	46	Fr2	E	E	E	E
49	47	Fr2	W	L	L	W
50	48	Fr2	I	V	V	I
51	49	Fr2	G	A	A	G
52	50	CDR-H2	E	S	E	E
53	51	CDR-H2	I	I	I	I
54	52	CDR-H2	N	N	N	N
55	52A	CDR-H2	P	S	P	P
56	52B	CDR-H2	—	—	—	—
57	52C	CDR-H2	—	—	—	—
58	53	CDR-H2	G	N	G	G
59	54	CDR-H2	S	G	S	S
60	55	CDR-H2	S	G	S	S
61	56	CDR-H2	T	S	T	T
62	57	CDR-H2	I	T	I	I
63	58	CDR-H2	N	Y	N	N
64	59	CDR-H2	Y	Y	Y	Y
65	60	CDR-H2	T	P	T	T

66	61	CDR-H2	P	D	P	P
67	62	CDR-H2	S	S	S	S
68	63	CDR-H2	L	V	L	L
69	64	CDR-H2	K	K	K	K
70	65	CDR-H2	D	G	D	D
71	66	Fr3	K	R	R	R
72	67	Fr3	F	F	F	F
73	68	Fr3	I	T	T	T
74	69	Fr3	I	I	I	I
75	70	Fr3	S	S	S	S
76	71	Fr3	R	R	R	R
77	72	Fr3	D	D	D	D
78	73	Fr3	N	N	N	N
79	74	Fr3	A	A	A	A
80	75	Fr3	K	K	K	K
81	76	Fr3	N	N	N	N
82	77	Fr3	T	S	S	S
83	78	Fr3	L	L	L	L
84	79	Fr3	F	Y	Y	Y
85	80	Fr3	L	L	L	L
86	81	Fr3	Q	Q	Q	Q
87	82	Fr3	M	M	M	M
88	82A	Fr3	S	N	N	N
89	82B	Fr3	K	S	S	S
90	82C	Fr3	V	L	L	L
91	83	Fr3	R	R	R	R
92	84	Fr3	S	A	A	A
93	85	Fr3	E	E	E	E
94	86	Fr3	D	D	D	D
95	87	Fr3	S	T	T	T
96	88	Fr3	A	A	A	A
97	89	Fr3	L	V	V	V
98	90	Fr3	Y	Y	Y	Y
99	91	Fr3	Y	Y	Y	Y
100	92	Fr3	C	C	C	C
101	93	Fr3	A	A	A	A
102	94	Fr3	R	S	S	R
103	95	CDR-H3	L	G	L	L
104	96	CDR-H3	G	—	G	G

105	97	CDR-H3	Y	_	Y	Y
106	98	CDR-H3	G	_	G	G
107	99	CDR-H3	N	_	N	N
108	100	CDR-H3	Y	_	Y	Y
109	100A	CDR-H3	G	_	G	G
110	100B	CDR-H3	W	_	W	W
111	100C	CDR-H3	A	_	A	A
112	100D	CDR-H3	L	_	L	L
113	100E	CDR-H3	_	_	_	_
114	100F	CDR-H3	_	_	_	_
115	100G	CDR-H3	_	_	_	_
116	100H	CDR-H3	_	_	_	_
117	100I	CDR-H3	_	_	_	_
118	100J	CDR-H3	_	_	_	_
119	100K	CDR-H3	_	_	_	_
120	101	CDR-H3	D	D	D	D
121	102	CDR-H3	Y	Y	Y	Y
122	103	Fr4	W	W	W	W
123	104	Fr4	G	G	G	G
124	105	Fr4	Q	Q	Q	Q
125	106	Fr4	G	G	G	G
126	107	Fr4	T	T	T	T
127	108	Fr4	S	T	T	T
128	109	Fr4	V	V	V	V
129	110	Fr4	T	T	T	T
130	111	Fr4	V	V	V	V
131	112	Fr4	S	S	S	S
132	113	Fr4	S	S	S	S

Table 10
V_H, V_L Backmutations and Other Mutations for Humanized 18C5

V_H or V_L Variant	V_H or V_L Exon Acceptor Sequence	Changes from Acceptor Framework Residues (based on Kabat/Chothia Composite CDRs)
hu18C5-VH_v1 (SEQ ID NO:85)	Acceptor 5VZY-VH_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO:83)	None
hu18C5-VH_v2 (SEQ ID NO:86)	Acceptor 5VZY-VH_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO:83)	H37, H45, H47, H48, H49, H94
hu18C5-VL_v1 (SEQ ID NO:91)	Acceptor 5VZY-VL_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO: 89)	none
hu18C5-VL_v2 (SEQ ID NO:92)	Acceptor 5VZY-VL_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO: 89)	L2, L45

Table 11

Kabat Numbering of Framework Residues (based on Kabat/Chothia Composite CDRs) for Backmutations and Other Mutations in Heavy Chains of Humanized 18C5 Antibodies

Kabat Residue #	Acceptor 5VZY-VH_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO:83)	Murine 18C5 VH (SEQ ID NO: 81)	hu18C5-VH_v1 (SEQ ID NO:85)	hu18C5-VH_v2 (SEQ ID NO:86)
H37	V	A	V	A
H45	L	Q	L	Q
H47	L	W	L	W
H48	V	I	V	I
H49	A	G	A	G
H94	S	R	S	R

Table 12

Kabat Numbering of Framework Residues (based on Kabat/Chothia Composite CDRs) for Backmutations and Other Mutations in Light Chains of Humanized 18C5 Antibodies

Kabat Residue #	Acceptor 5VZY-VL_huFrwk (CreneFab) Acc. # 5VZY (SEQ ID NO: 89)	<u>Murine 18C5 VL (SEQ ID NO:87)</u>	hu18C5-VL_v1 (SEQ ID NO:91)	hu18C5-VL_v2 (SEQ ID NO:92)
L2	I	V	I	V
L45	Q	K	Q	R

Table 13**Percentage Humanness of Heavy and Light Chains of Humanized 18C5 Antibodies**

V_H or V_L Variant	% Humanness
hu18C5-VH_v1 (SEQ ID NO:85)	96.2%
hu18C5-VH_v2 (SEQ ID NO:86)	93.8%
hu18C5-VL_v1 (SEQ ID NO:91)	88.6%
hu18C5-VL_v2 (SEQ ID NO:92)	92.4%

[0435] Positions at which Chothia class canonical, vernier, or interface/packing residues differ between mouse and human acceptor sequences are candidates for substitution. Examples of Chothia class canonical residues include Kabat residue H48 in Tables 8 and 9. Examples of interface/packing (VH+VL) residues include Kabat residues H35, H37, H39, H45, H47, H91, H93, H95, H103, L34, L36, L38, L44, L46, L87, L89, L91, L96, and L98 in Tables 8 and 9.

[0436] The rationales for selection of the positions indicated in Table 8 in the light chain variable region as candidates for substitution are as follows.

I2V is a backmutation of a Chothia canonical residue.

Q45R is a mutation to IGKV2-30*02 germline residue. Q is rare in human at this position. R is frequent at this position.

[0437] *hu18C5-VL_v1*: CDR-L1, L2, and L3 loops of 18C5-VL grafted onto the framework of CreneFab (5VZY-VL).

[0438] *hu18C5-VL_v2*: reverts all framework substitutions at positions that are key for defining the Chothia canonical classes, are part of the Vernier zone, or locate to the VH/VL domain interface; hu18C5-VL_v2 incorporates backmutations I2V and human acceptor to germline mutation Q45R, to enable assessment of these positions' contributions to antigen-binding affinity and immunogenicity.

[0439] Light chain variable regions:

[0440] hu18C5-VL_1 (SEQ ID NO: 91)

DIVMTQSPLSLPVTGPGEPAISCRSSQSIVDSNGNTYLEWYLQKPGQSPQLLIYKVSNRFS
GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPLTFGQGTKVEIK

[0441] hu18C5-VL_2 (SEQ ID NO: 92)

DVVMTQSPLSLPVTGPGEPAISCRSSQSIVDSNGNTYLEWYLQKPGQSPRLLIYKVSNRFS
GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPLTFGQGTKVEIK

[0442] The rationales for selection of the positions indicated in Table 9 in the heavy chain variable region as candidates for substitution are as follows.

V37A: is a backmutation in the vernier zone. Val shows repulsive interaction with Trp47.

L45Q: is a backmutation of a core interface residue per Chothia. Leu at this position has repulsive Van der Waals interactions.

L47W: is a backmutation of an interface residue. In murine 18C5 Trp is at 47 position and Trp makes hydrogen bond with Ser 35 thereby stabilizing intra-chain beta-sheets. Leu does not establish any interface with any residue and may destabilize conformation.

V48I: is a backmutation of a CDR interacting Vernier zone residue to preserve this interaction.

A49G: is a backmutation of a Vernier zone residue.

S94R: is a backmutation of a Vernier zone residue, to preserve CDR interaction.

[0443] *hu18C5-VH_v1*: CDR-H1, H2, and H3 loops of 18C5-VH grafted onto the framework of CreneFab VH (5VZY-VH).

[0444] *Hu18C5-VH_v2*: reverts all framework substitutions at positions that are key for defining the Chothia canonical classes, are part of the Vernier zone, or localize to the VH/VL domain interface. 18C5-VH_v2 incorporates backmutations V37A, L45Q, L47W, V48I, A49G and S94R, to enable assessment of these positions' contributions to antigen-binding affinity and immunogenicity.

[0445] Heavy chain variable regions:

[0446] hu18C5-VH_1 (SEQ ID NO: 85)

EVQLVESGGGLVQPGGSLRLSCAASGFDLSRFWMSWVRQAPGKGLELVAEINPGSSTIN
YTPSLKDRFTISRDNANKNSLYLQMNSLRAEDTAVYYCASLGYGNYGWALDYWGQGT
TVSS

[0447] hu18C5-VH_2 (SEQ ID NO: 86)

EVQLVESGGGLVQPGGSLRLSCAASGFDLSRFWMSWARQAPGKGQEWIGEINPGSSTIN
YTPSLKDRFTISRDNANKNSLYLQMNSLRAEDTAVYYCARLGYGNYGWALDYWGQGT
TVSS

Sequence Listing:

SEQ ID NO:1

18C5 VH amino acid sequence with signal peptide

MDFGLIFFIVALLKGVQCEVKLLESGGGLVQPGGSLNLSCVASGFDFSRFWMSWARQAP
GRGQEWIGEINPGSSTINYTPSLKDKFIISRDNAKNTLFLQMSKVRSEDSALYYCARLGY
GNYGWALDYWGQGTSVTVSS

SEQ ID NO:2

nucleotide sequence encoding mouse 18C5 VH with signal peptide

ATGGATTTTGGGCTGATTTTTTTCATTGTTGCCCTTTTAAAAGGGGTCCAGTGTGAGGT
AAAGCTTCTCGAGTCTGGAGGTGGCCTGGTGCAGCCTGGAGGATCCCTGAATCTCTC
CTGTGTAGCCTCAGGATTCGATTTTAGTAGATTCTGGATGAGTTGGGCTCGGCAGGCT
CCAGGGAGAGGACAGGAATGGATTGGAGAGATTAATCCAGGAAGCAGTACGATAAA
CTATACGCCATCTCTGAAGGATAAATTCATCATCTCCAGAGACAACGCCAAAAATACG
CTGTTCTGCAAATGAGCAAAGTGAGATCTGAGGACTCAGCCCTTTATTACTGTGCAA
GACTGGGGTATGGTAACTACGGATGGGCTCTGGACTACTGGGGTCAAGGAACCTCAG
TCACCGTCTCCTCA

SEQ ID NO:3

18C5 VL amino acid sequence with signal peptide

MKLPRLLVLMFWIPASRSDVLMQTPLSLPVS LGDQASISCRSSQSIVDSNGNTYLEWY
LQKPGQSPKLLIYKVS NRFS GVPDRFSGSGSGTDFTLKISRVEAEDLGIYYCFQGSHVPLT
FGAGTKLELK

SEQ ID NO:4

nucleotide sequence encoding mouse 18C5 VL with signal peptide

ATGAAGTTGCCTGTTAGGCTGTTGGTGCTGATGTTCTGGATTCCTGCTTCCAGAAGTG
ATGTTTTGATGACCCAAACTCCACTCTCCCTGCCTGTCAGTCTTGGAGATCAAGCCTC
CATCTCTTGCAGATCTAGTCAGAGCATTGTAGATAGTAATGGAAACACCTATTTAGAAT
GGTACCTGCAGAAACCAGGCCAGTCTCCAAAGCTCCTGATCTACAAAGTTTCCAACC
GATTTTCTGGGGTCCCAGACAGGTTCAAGTGGCAGTGGATCAGGGACAGATTCACAC

TCAAGATCAGCAGAGTGGAGGCTGAGGATCTGGGAATTTATTACTGCTTTCAAGGTTCT
ACATGTTCCGCTCACGTTTCGGTGCTGGGACCAAGTTGGAGCTGAAA

SEQ ID NO: 5

amino acid sequence of an 18C5 CDR-H1

GFDFSRLFWS

SEQ ID NO: 6

nucleic acid sequence encoding an 18C5 CDR-H1

GGATTTCGATTTTAGTAGATTCTGGATGAGT

SEQ ID NO: 7

amino acid sequence of an 18C5 CDR-H2

EINPGSSTINYTPSLKD

SEQ ID NO: 8

nucleic acid sequence encoding an 18C5 CDR-H2

GAGATTAATCCAGGAAGCAGTACGATAAACTATACGCCATCTCTGAAGGAT

SEQ ID NO: 9

amino acid sequence of an 18C5 CDR-H3

LGYGNYGWALDY

SEQ ID NO: 10

nucleic acid sequence encoding an 18C5 CDR-H3

CTGGGGTATGGTAACTACGGATGGGCTCTGGACTAC

SEQ ID NO: 11

amino acid sequence of an 18C5 CDR-L1

RSSQSIVDSNGNTYLE

SEQ ID NO: 12

nucleic acid sequence encoding an 18C5 CDR-L1

AGATCTAGTCAGAGCATTGTAGATAGTAATGGAAACACCTATTTAGAA

SEQ ID NO: 13

amino acid sequence of an 18C5 CDR-L2

KVSNRFS

SEQ ID NO: 14

nucleic acid sequence encoding an 18C5 CDR-L2

AAAGTTTCCAACCGATTTTCT

SEQ ID NO: 15

amino acid sequence of an 18C5 CDR-L3

FQGSHVPLT

SEQ ID NO: 16

nucleic acid sequence encoding an 18C5 CDR-L3

TTTCAAGGTTACATGTTCCGCTCACG

SEQ ID NO: 17

amino acid sequence of a chimeric 18C5 heavy chain constant region (human IgG1)

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQY
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSR
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO: 18

nucleic acid encoding a chimeric 18C5 heavy chain constant region (human IgG1)

GCCTCCACCAAGGGCCCATCGGTCTTCCCCCTGGCACCCCTCCTCCAAGAGCACCTCT
GGGGGCACAGCGGCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGAC
GGTGTCGTGGAAGTCAAGGCGCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCT
ACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTT
GGGCACCCAGACCTACATCTGCAACGTGAATCACAAGCCCAGCAACACCAAGGTGG
ACAAGAGAGTTGAGCCCCAATCTTGTGACAAAACCTCACACATGCCCACCGTGCCCAG
CACCTGAACTCCTGGGGGGACCGTCAGTCTTCTCTTCCCCC AAAACCCAAGGACA
CCCTCATGATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACG
AAGACCCTGAGGTCAAGTTCAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCA
AGACAAAGCCGCGGGAGGAGCAGTACAACAGCACGTACCGTGTGGTTCAGCGTCCTC
ACCGTCCTGCACCAGGACTGGCTGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAA
CAAAGCCCTCCCAGCCCCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCC
GAGAACCACAGGTGTACACGCTGCCCCCATCCCGGGAGGAGATGACCAAGAACCAG
GTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAGTGG
GAGAGCAATGGGCAGCCGGAGAACAACCTACAAGACCACGCCTCCCGTGGTGGACTC
CGACGGCTCCTTCTTCTCTATAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCA
GGGGAACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACGCA
GAAGAGCCTCTCCCTGTCCCCGGGTAAATGA

SEQ ID NO: 19

amino acid sequence of a chimeric 18C5 light chain constant region (human kappa)

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQ
DSKDSTYLSSTLTLSKADYEEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO: 20

nucleic acid sequence encoding an amino acid sequence of a chimeric 18C5 light chain
constant region (human kappa)

CGGGGAAGTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGA
AATCTGGAAGTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAA

AGTACAGTGGAAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTAC
AGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCTGACGCTGAGCA
AAGCAGACTACGAGAAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTG
AGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGTTAG

SEQ ID NO:21

amino acid sequence of an exemplary IgG1 heavy chain constant region

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNVKTKPREEQY
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSR
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO:22

amino acid sequence of an exemplary IgG1 G1m3 heavy chain constant region

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQY
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSR
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO:23

amino acid sequence of an exemplary IgG1 G1m3 heavy chain constant region

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSS
GLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAEAAGG
PSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQY
NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSR
EEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO:24

amino acid sequence of an exemplary light chain constant region with N-terminal
Arginine

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQ
DSKDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:25

amino acid sequence of an exemplary light chain constant region without N-terminal
Arginine

TVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQD
SKDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:26

amino acid sequence of human transthyretin set forth in accession number P02766.1
(UniProt)

MASHRLLLLCLAGLVFVSEAGPTGTGESKCPLMVKVLDVAVRGSPAINVAVHVFRKAADD
TWEPFASGKTSESGELHGLTTEEEFVEGIYKVEIDTKSYWKALGISPFHEHAEEVVFTANDS
GPRRYTIAALLSPYSYSTTAVVTNPKE

SEQ ID NO:27

amino acid sequence of human transthyretin set forth in accession number AAB35639.1
(GenBank)

GPTGTGESKCPLMVKVLDVAVRGSPAINVAVHVFRKAADDTWEPFASGKTSESGELHGLT
TEEQFVEGIYKVEIDTKSYWKALGISPFHEHAEEVVFTANDSGPRRYTIAALLSPYSYSTTA
VVTNPKE

SEQ ID NO:28

amino acid sequence of human transthyretin set forth in accession number AAB35640.1
(GenBank)

GPTGTGESKCPLMVKVLDVAVRGSPAINVAVHVFRKAADDTWEPFASGKTSESGELHGLT
TEEQFVEGIYKVEIDTKSYWKALGISPFHEHAEEVVFTANDSGPRRYTIAALLSPYSYSTTA
VVTNPKE

SEQ ID NO:29

amino acid sequence of human transthyretin set forth in accession number and
ABI63351.1 (GenBank)

MASHRLLLLCLAGLVFVSEAGPTGTGESKCPLMVKVLDVAVRGSPAINVAVHVFRKAADD
TWEPFASGKTSESGELHGLTTEEEFVEGIYKVEIDTKSYWKALGISPFHEHAEEVFTANDS
GPRRYSYSTTAVVTNPKE

SEQ ID NO:30

amino acid sequence of residues 101-109 of human transthyretin

GPRRYTIAA

SEQ ID NO:31

amino acid sequence of residues 87-127 of human transthyretin

FHEHAEEVFTANDSGPRRYTIAALLSPYSYSTTAVVTNPKE

SEQ ID NO:32

nucleic acid sequence encoding an exemplary IgG1 G1m3 heavy chain constant region

GCCTCCACCAAGGGTCCATCGGTCTTCCCCCTGGCACCCCTCCTCCAAGAGCACCTCT
GGGGGCACAGCGGCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGAC
GGTGTCTGTTGAACTCAGGCGCCCTGACCAGCGGCGTGACACCTTCCCGGCTGTCTCT
ACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTT
GGGCACCCAGACCTACATCTGCAACGTGAATCACAAGCCCAGCAACACCAAGGTGG
ACAAGAGAGTTGAGCCCAAATCTTGTGACAAACTCACACATGCCACCGTGCCAG
CACCTGAACCTCTGGGGGGACCGTCAGTCTTCTCTTCCCCCAAACCCAAGGACA
CCCTCATGATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACG
AAGACCCTGAGGTCAAGTTCAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCA
AGACAAAGCCGCGGGAGGAGCAGTACAACAGCACGTACCGTGTGGTCAGCGTCCTC
ACCGTCCTGCACCAGGACTGGCTGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAA
CAAAGCCCTCCCAGCCCCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCC
GAGAACCACAGGTGTACACCCTGCCCCCATCCCGGGAGGAGATGACCAAGAACCAG
GTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAGTGG
GAGAGCAATGGGCAGCCGAGAACTACAAGACCACGCCTCCCGTGCTGGACTC
CGACGGCTCCTTCTTCTCTATAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCA
GGGGAACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACGCA
GAAGAGCCTCTCCCTGTCCCCGGGTAAA

SEQ ID NO:33

nucleic acid sequence encoding an exemplary light chain constant region with N-terminal Arginine

CGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAAT
CTGGAAGTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGT
ACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTACAG
AGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCTGACGCTGAGCAAA
GCAGACTACGAGAAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAG
CTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT

SEQ ID NO:34

nucleic acid sequence encoding an exemplary light chain constant region without N-terminal Arginine

ACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTG
GAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACA
GTGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTACAGAGC
AGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCTGACGCTGAGCAAAGCA
GACTACGAGAAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGCTC
GCCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT

SEQ ID NO:35

amino acid sequence of a heavy chain constant region signal peptide

MNFGLSLIFLVVLKGVQC

SEQ ID NO:36

nucleic acid sequence encoding a heavy chain constant region signal peptide

ATGAACTTTGGGCTCAGCTTGATTTTCCTTGTCTTGTCTTTAAAGGTGTCCAGTGT

SEQ ID NO:37

amino acid sequence of a light chain constant region signal peptide

MESHTQVFVFLWLSGVDG

SEQ ID NO:38

nucleic acid sequence encoding a light chain constant region signal peptide

ATGGAGTCACATACTCAGGTCTTTGTATTTCGTGTTTCTCTGGTTGTCTGGTGTGACGG
A

SEQ ID NO: 39

amino acid sequence of a Kabat CDR-H1 of 14G8
SYTMS

SEQ ID NO: 40

amino acid sequence of a Kabat CDR-H2 of 14G8
EINNSGDTTYYPDTVKG

SEQ ID NO: 41

amino acid sequence of a Kabat CDR-H3 of 14G8
HYYYGGGYGGWFFDV

SEQ ID NO: 42

amino acid sequence of a Kabat CDR-L1 of 14G8
RSNKSLLHSNGNTYLY

SEQ ID NO: 43

amino acid sequence of a Kabat CDR-L2 of 14G8
RVSNLAS

SEQ ID NO: 44

amino acid sequence of a Kabat CDR-L3 of 14G8
MQHLEYPLT

SEQ ID NO: 45

epitope of 5A1
EHAENVFTA

SEQ ID NO: 46

amino acid sequence of a Kabat CDR-H1 of 5A1
NYAMS

SEQ ID NO: 47

amino acid sequence of a Kabat CDR-H2 of 5A1

SISSGGSTYYPDSVKG

SEQ ID NO: 48

amino acid sequence of a Kabat CDR-H3 of 5A1

YYYGQYFDF

SEQ ID NO: 49

amino acid sequence of a Kabat CDR-L1 of 5A1

KASQDVSTTVA

SEQ ID NO: 50

amino acid sequence of a Kabat CDR-L2 of 5A1

SASYRCT

SEQ ID NO: 51

amino acid sequence of a Kabat CDR-L3 of 5A1

QQHYSTPLT

SEQ ID NO: 52

amino acid sequence of a Kabat CDR-H1 of 6C1

NYYMS

SEQ ID NO: 53

amino acid sequence of a Kabat CDR-H2 of 6C1

YISIDGNNIYHPDSVKG

SEQ ID NO: 54

amino acid sequence of a Kabat CDR-H3 of 6C1

DSDYGYFDV

SEQ ID NO: 55

amino acid sequence of a Kabat CDR-L1 of 6C1

RSSQSIVHSNGNTYLE

SEQ ID NO: 56

amino acid sequence of a Kabat CDR-L2 of 6C1

KVSKRFS

SEQ ID NO: 57

amino acid sequence of a Kabat CDR-L3 of 6C1

FQGSHVPLT

SEQ ID NO: 58

amino acid sequence of VH region of AD7F6

EVQLVESGGDLVKPGGSLKLSCAASGFTFSNYGMSWIRQTPDKRLEWVATISSSGTYTYT
TESVKGRFTVSRDNAKNTLSLQMSNLKSDDTAMYYCTRQAYGREYFDVWGTGTTVT
SSAKTTPPSVYPLAPGCGDTTGSSVTLGCLVKGYFPESVTVTWNSGSLSSSVHTFPALLQS
GLYTMSSSVTVPSSTWPSQTVTCSVAHPASSTTVDKKLEPSGPISTINPCPPCKECKCPAP
NLEGGPSVFIFPPNIKDVLMLSLTPKVTCTVVDVSEDDPDVRISWVFNVEVHTAQTQTH
REDYNSTIRVVSALPIQHQQDWMSGKEFKCKVNNKDLPSPIERTISKIKGLVRAPQVYILPP
PAEQLSRKDVSLTCLVVGFNPGDISVEWTSNGHTEENYKDTAPVLDSGSGYFIYSKLDIK
TSTVGENRFLLMQRETRGSEKLLPEEDHLPSPGK

SEQ ID NO: 59

amino acid sequence of VL region of AD7F6

DIVMSQSPSSLAVSAGEKVTMSCKSSQSLFDSRTRKNYLAWYQQKPGQSPKLLIYWASN
RESGVPDRFIGSGSGTDFTLTISVQAEDLAVYFCKQSNYLRTFGGGTRVEIKRADAAPT
SIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQNGVLNSWTDQDSKSTYS
MSSTLTTLTKDEYERHNSYTCEATHKTSTSPIVKSFNRNEC

SEQ ID NO: 60

amino acid sequence of CDR-H1 of RT24

RYWIT

SEQ ID NO: 61

amino acid sequence of CDR-H2 of RT24

DIYPGSGRTNYNEKFKN

SEQ ID NO: 62

amino acid sequence of CDR-H3 of RT24

YYGSTYFYV

SEQ ID NO: 63

amino acid sequence of CDR-L1 of RT24

RSSKSLLYKDGKTYLN

SEQ ID NO: 64

amino acid sequence of CDR-L2 of RT24

LMSTRAS

SEQ ID NO: 65

amino acid sequence of CDR-L3 of RT24

QQLVEYPRT

SEQ ID NO: 66

amino acid sequence of CDR-H1 of NI-301.35G11

SYAMS

SEQ ID NO: 67

amino acid sequence of CDR-H2 of NI-301.35G11

SISGSGDTTKYTDSVKG

SEQ ID NO: 68

amino acid sequence of CDR-H3 of NI-301.35G11

DGSGRIDPFAL

SEQ ID NO: 69

amino acid sequence of CDR-L1 of NI-301.35G11

RSSRSLVYSDGNIYLN

SEQ ID NO: 70

amino acid sequence of CDR-L2 of NI-301.35G11

KVSNRDSG

SEQ ID NO: 71

amino acid sequence of CDR-L3 of NI-301.35G11

MQGTHWPRT

SEQ ID NO: 72

epitope of MFD101, MDF102, MFD103, MFD105,

ADDTWEPFASGKT

SEQ ID NO: 73

epitope of MFD107, MFD108, MFD109, MFD111

TSESGELHGLTTE

SEQ ID NO: 74

epitope of MFD114

ALLSPYSYSTTAV

SEQ ID NO: 75

amino acid sequence of a Kabat CDR-H1 of antibody 9D5

SYTMS

SEQ ID NO: 76

amino acid sequence of a Kabat CDR-H2 of antibody 9D5

EISNSGDTTYYPDTVKG

SEQ ID NO: 77

amino acid sequence of a Kabat CDR-H3 of antibody 9D5

HYYYGGGYGGWFFDV

SEQ ID NO: 78

amino acid sequence of a Kabat CDR-L1 of antibody 9D5

RSSKSLLHSNGNTYLY

SEQ ID NO: 79

amino acid sequence of a Kabat CDR-L2 of antibody 9D5

RVSNLAS

SEQ ID NO: 80

amino acid sequence of a Kabat CDR-L3 of antibody 9D5

MQHLEYPLT

SEQ ID NO: 81

amino acid sequence of a mature heavy chain variable region of the mouse 18C5
antibody

EVKLLES GGGLVQPGGSLNLSCVASGFDFSRFWMSWARQAPGRGQEWIGEINPGSSTIN
YTPSLKDKFIISRDNAKNTLFLQMSKVRSEDSALYYCARLGYGNYGWALDYWGQGTSV
TVSS

SEQ ID NO: 82

amino acid sequence of a heavy chain variable region of the murine anti-pyroglutamate-
Abeta antibody Fab c#17

EVKLVESGGGLVQPGGSRKLSAASGFTFSDYGMAWVRQAPGKGPEWVAFISNLAYSI
YYADTVTGRFTISRENAKNTLYLEMSSLRSEDAMYYCARYDYDNILDYVMDYWGQG
TSVTVSS

SEQ ID NO: 83

amino acid sequence of a heavy chain variable region of humanized Crenezumab Fab
(CreneFab) PDB: 5VZY

EVQLVESGGGLVQPGGSLRLSCAASGFTFSSYGMSWVRQAPGKGLELVASINSNGGSTY
YPDSVKGRFTISRDNKNSLYLQMNSLRAEDTAVYYCASGDYWGQGTTVTSS

SEQ ID NO: 84

amino acid sequence of a heavy chain variable region of the human germline sequence
IGHV3-48*01

EVQLVESGGGLVQPGGSLRLSCAASGFTFSSYSMNWVRQAPGKGLEWVSYISSSSTIY
YADSVKGRFTISRDNKNSLYLQMNSLRAEDTAVYYCARYFDYWGQGTLLTVSS

SEQ ID NO: 85

amino acid sequence of a heavy chain variable region of the humanized 18C5 antibody
hu18C5-VH_1

EVQLVESGGGLVQPGGSLRLSCAASGFDFSRFWMSWVRQAPGKGLELVAEINPGSSTIN
YTPSLKDRFTISRDNKNSLYLQMNSLRAEDTAVYYCASLGYGNYGWALDYWGQGT
TVSS

SEQ ID NO: 86

amino acid sequence of a heavy chain variable region of the humanized 18C5 antibody
hu18C5-VH_2

EVQLVESGGGLVQPGGSLRLSCAASGFDFSRFWMSWARQAPGKGQEWIGEINPGSSTIN
YTPSLKDRFTISRDNKNSLYLQMNSLRAEDTAVYYCARLGYGNYGWALDYWGQGT
TVSS

SEQ ID NO: 87

amino acid sequence of a mature light chain variable region of the mouse 18C5 antibody
DVLMTQTPLSLPVSLGDQASISCRSSQSIVDSNGNTYLEWYLQKPGQSPKLLIYKVSNRFS
SGVPDRFSGSGSGTDFTLKISRVEAEDLGIYYCFQGSHVPLTFGAGTKLELK

SEQ ID NO: 88

amino acid sequence of a light chain variable region of the murine anti-pyroglutamate-
Abeta antibody Fab c#17
DVVMTQTPLSLPVSLGDQASISCRSSQSLVHSDGNTYLHWYLQKPGQSPKLLIYKVSNRFS
FSGVPDRFSGSGSGTDFTLKISRVEAEDLGVYFCSQSTHVPPTFGGGTKLEIK

SEQ ID NO: 89

amino acid sequence of a light chain variable region of humanized Crenezumab Fab
(CreneFab) PDB: 5VZY
DIVMTQSPLSLPVTGPGEASISCRSSQSLVYSNGDTYLHWYLQKPGQSPQLLIYKVSNRFS
GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCSQSTHVPWTFGQGTKVEIK

SEQ ID NO: 90

amino acid sequence of a light chain variable region of the human germline sequence
IGKV2-30*2
DVVMTQSPLSLPVTLGQPASISCRSSQSLVHSDGNTYLNWFQQRPGQSPRRLIYKVSNRD
SGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCMQGTHWPWTFGQGTKVEIK

SEQ ID NO: 91

amino acid sequence of a light chain variable region of the humanized 18C5 antibody
hu18C5-VL_1
DIVMTQSPLSLPVTGPGEASISCRSSQSIVDSNGNTYLEWYLQKPGQSPQLLIYKVSNRFS
GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPLTFGQGTKVEIK

SEQ ID NO: 92

amino acid sequence of a light chain variable region of the humanized 18C5 antibody

hu18C5-VL_2

DVVMTQSPLSLPVTPGEPASISCRSSQSIVDSNGNTYLEWYLQKPGQSPRLLIYKVSNRFS
GVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCFQGSHVPLTFGQGGTKVEIK

SEQ ID NO: 93

amino acid sequence of Kabat CDR-H1 of the mouse 18C5 antibody

RFWMS

SEQ ID NO: 94

amino acid sequence of Chothia CDR-H1 of the mouse 18C5 antibody

GFDFS RF

SEQ ID NO: 95

amino acid sequence of Contact CDR-H1 of the mouse 18C5 antibody

SRFWMS

SEQ ID NO: 96

amino acid sequence of Chothia CDR-H2 of the mouse 18C5 antibody

NPGSST

SEQ ID NO: 97

amino acid sequence of AbM CDR-H2 of the mouse 18C5 antibody

EINPGSSTIN

SEQ ID NO: 98

amino acid sequence of Contact CDR-H2 of the mouse 18C5 antibody

WIGEINPGSSTIN

SEQ ID NO: 99

amino acid sequence of Contact CDR-H3 of the mouse 18C5 antibody
ARLGYGNYGWALD

SEQ ID NO: 100

amino acid sequence of Contact CDR-L1 of the mouse 18C5 antibody
NTYLEWY

SEQ ID NO: 101

amino acid sequence of Contact CDR-L2 of the mouse 18C5 antibody
LLIYKVSNR

SEQ ID NO: 102

amino acid sequence of Contact CDR-L3 of the mouse 18C5 antibody
FQGSHVPL

SEQ ID NO: 103

9D5 mouse VH amino acid sequence
EVKLVESGGGLVQPGGSLKLSAASGFTFSSYTMSWVRQTPEKRLELVAEISNSGDDTY
YPTDVKGRFTFSRDNAKNTLYLQMSSLKSEDTAMYYCARHYYYGGGYGGWFFDVWG
TGTTVTVSS

SEQ ID NO: 104

9D5 mouse VL amino acid sequence
DIVMTQAAPSVPTPGESVSISRSSKSLLSNGNTLYWFLQRPQGSPQLLIYRVSNLA
SGVPDRFSGSGGTFTLRISRVEAEDVGVYYCMQHLEYPLTFGAGTKLELK

WHAT IS CLAIMED IS:

1. A method of detecting misfolded transthyretin (TTR) in a biological sample, the method comprising:
 - (a) contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and
 - (b) detecting the reporter antibody that forms a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.
2. The method of claim 1, wherein the biological sample is from a hereditary ATTR patient.
3. The method of claim 2, wherein the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, G47R, S50I, T49S, F33V, A45T, E89K, E89Q, and V122I.
4. The method of claim 3, wherein the mutation is selected from the group consisting of V30M, Y114C, and S50I.
5. The method of claim 3, wherein the mutation is V30M.
6. The method of claim 3, wherein the mutation is Y114C.
7. The method of claim 3, wherein the mutation is S50I.
8. The method of claim 3, wherein the mutation is E89K.
9. The method of claim 3, wherein the mutation is E89Q.
10. The method of claim 1, wherein the capture antibody is 9D5.
11. The method of claim 10, wherein the capture antibody is 9D5 and the reporter antibody is a polyclonal anti-TTR antibody.

12. The method of any of claims 1-10, wherein the reporter antibody is 18C5, 8C3, 7G7, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof or a polyclonal anti-TTR antibody.

13. The method of claim 1 or 2, wherein the capture antibody is 9D5 and the reporter antibody is 18C5, or a chimeric version or humanized version thereof.

14. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is 8C3, or a chimeric version or humanized version thereof.

15. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is 7G7, or a chimeric version or humanized version thereof.

16. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is AD7F6, or a chimeric version or humanized version thereof.

17. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is RT24, or a chimeric version or humanized version thereof.

18. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is NI-301.35G11, or a chimeric version or humanized version thereof.

19. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD101, or a chimeric version or humanized version thereof.

20. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MDF102, or a chimeric version or humanized version thereof.

21. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD103, or a chimeric version or humanized version thereof.

22. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD105, or a chimeric version or humanized version thereof.

23. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD107, or a chimeric version or humanized version thereof.
24. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD108, or a chimeric version or humanized version thereof.
25. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD109, or a chimeric version or humanized version thereof.
26. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD111, or a chimeric version or humanized version thereof.
27. The method of claim 1, wherein the capture antibody is 9D5 and the reporter antibody is MFD114, or a chimeric version or humanized version thereof.
28. The method of claims 1-10, wherein the reporter antibody is an antibody that binds within residues 101-109, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or 115-127 of TTR.
29. The method of any preceding claim, wherein the misfolded TTR includes an E89K substitution.
30. The method of any preceding claim, wherein the misfolded TTR includes an E89Q substitution.
31. The method of claim 1-30, wherein the biological sample is a first aliquot of a collected sample and the method further comprises repeating step (a) and (b) on a second aliquot of the collected sample further comprising a test antibody that competes with the capture antibody for binding to TTR, wherein reduced reporter antibody forming the sandwich complex on repeating the steps provides an indication of the test antibody's ability to bind to misfolded TTR.
32. The method of claim 31, wherein the test antibody is 14G8 or a chimeric or humanized form thereof, the capture antibody is 9D5, and the reporter antibody is a polyclonal anti-TTR antibody.

33. The method of claim 32 wherein the test antibody is a humanized form of 14G8.

34. A method of determining in vivo target engagement of a test antibody administered to a subject, which target is an epitope within residues 89-97 of misfolded transthyretin (mis-TTR) by detecting the mis-TTR remaining in a biological sample from the subject treated with the test antibody, the method comprising:

(a) contacting the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 and a reporter antibody that specifically binds to a different epitope within TTR from that of the capture antibody; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(b) detecting the reporter antibody forming a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.

35. The method of claim 34, wherein the wherein the biological sample is from a hereditary ATTR patient.

36. The method of claim 35, wherein the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, G47R, S50I, T49S, F33V, A45T, E89K, E89Q, and V122I.

37. The method of claim 36, wherein the mutation is selected from the group consisting of V30M, Y114C, and S50I.

38. The method of claim 36, wherein the mutation is V30M.

39. The method of claim 36, wherein the mutation is Y114C.

40. The method of claim 36, wherein the mutation is S50I.

41. The method of claim 36, wherein the mutation is E89K.

42. The method of claim 36, wherein the mutation is E89Q.

43. The method of claim 34 or 35, wherein a reduction of detection of misfolded TTR in the treated subject relative to the detection of misfolded TTR in a biological sample from an untreated subject correlates with positive target engagement and treating the subject with the same or a lesser amount of the test antibody.

44. The method of claim 35, wherein the treated subject and the untreated subject are the same individual.

45. The method of claim 34, wherein the capture antibody is 9D5 and the reporter antibody is 9D5, wherein the capture antibody and the reporter antibody have different labels.

46. The method of claim 34, wherein the capture antibody is 9D5 and the reporter antibody is 14G8.

47. The method of claim 34, wherein the capture antibody is 9D5 and the reporter antibody is 5A1.

48. The method of claim 34, wherein the capture antibody is 9D5 and the reporter antibody is 6C1.

49. The method of claim 45, wherein the reporter antibody competes for binding with the capture antibody for binding multimeric misfolded transthyretin.

50. The method of any preceding claim, wherein the reporter antibody has an electrochemiluminescent label and is detected by electrochemiluminescence.

51. The method of any preceding claim, wherein the capture antibody has a biotin label.

52. The method of any preceding claim, performed qualitatively.

53. The method of any preceding claim, performed quantitatively to indicate an absolute or relative amount of the misfolded TTR.

54. The method of any preceding claim, wherein the capture antibody is bound to a solid phase before the contacting step.
55. The method of claim 54, wherein the capture antibody is attached to the solid phase via a linker.
56. The method of claim 54, wherein the solid phase comprises at least one electrode.
57. The method of any preceding claim, further comprising: comparing a signal from the reporter antibody with a signal from the reporter antibody in a control sample containing a known amount of misfolded TTR to determine the amount of misfolded TTR in the sample.
58. The method of any preceding claim, further comprising comparing a signal from the reporter antibody from a calibration curve of signal versus amount of misfolded TTR to determine the amount of misfolded TTR in the sample.
59. The method of any preceding claim, wherein a signal from the reporter antibody is proportional to the amount of misfolded TTR in the sample.
60. The method of any preceding claim, wherein the sample is a sample from a human.
61. The method of any preceding claim, wherein the sample is a body fluid.
62. The method of any preceding claim, wherein the sample is plasma of a human.
63. The method of any preceding claim, wherein presence of misfolded TTR is used to diagnose a subject from whom the sample was obtained with a transthyretin-mediated amyloidosis.
64. The method of claim 63, wherein the transthyretin-mediated amyloidosis is a familial transthyretin amyloidosis or a sporadic wild-type transthyretin amyloidosis.

65. The method of claim 64, wherein the subject has been identified as at risk of a familial transthyretin amyloidosis based on genetic testing.

66. The method of claim 64, wherein the subject does not show symptoms of a familial transthyretin amyloidosis.

67. The method of claim 66 wherein the subject does not have polyneuropathy or cardiomyopathy.

68. The method of claim 64, wherein the familial transthyretin amyloidosis is familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA).

69. The method of any preceding claim, wherein the biological sample is from a patient receiving treatment for a transthyretin-mediated amyloidosis.

70. A method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising

(a) comparing the amount of misfolded TTR detected by the method of claim 34 or 35 in a sample from a subject previously treated for transthyretin mediated amyloidosis with the amount of misfolded TTR detected in the subject prior to treatment or during an earlier stage of treatment; and

(b) increasing the dose or frequency of administration of the prior treatment if the amount of misfolded TTR is the same or greater than that previously detected; or

(c) decreasing the dose or frequency of administration of the prior treatment or discontinuing the prior treatment if the amount of misfolded TTR is less than that previously detected.

71. The method of claim 70, wherein the prior treatment is by intravenous administration of an anti-TTR antibody and if the amount of misfolded TTR is less than that previously detected, the prior treatment is discontinued and replaced with treatment with a TTR stabilizer, antisense oligonucleotide based therapy, RNA interference therapy or combination therapy with doxycycline and tauroursodeoxycholic acid.

72. The method of claim 71, wherein the subject no longer receives treatment with the anti-TTR antibody.

73. The method of claim 71, wherein the TTR tetramer stabilizer is tafamidis or diflunisal.

74. The method of claim 71, wherein the TTR tetramer stabilizer is diflunisal.

75. The method of claim 71, wherein the antisense oligonucleotide based therapeutic is inotersen.

76. The method of claim 71, wherein the RNAi based therapeutic is patisiran or revusiran.

77. The method of claim 71, wherein the anti-TTR antibody is 14G8.

78. The method of claim 77, wherein the subject no longer receives treatment with the anti-TTR antibody.

79. The method of claim 77, wherein the TTR tetramer stabilizer is tafamidis or diflunisal.

80. The method of claim 77, wherein the TTR tetramer stabilizer is diflunisal.

81. The method of claim 77, wherein the antisense oligonucleotide based therapeutic is inotersen.

82. The method of claim 77, wherein the RNAi based therapeutic is patisiran or revusiran.

83. A method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising

(a) comparing the amount of reporter antibody binding detected by the method of claim 51 in a sample from a subject before initiating treatment for transthyretin mediated

amyloidosis with the amount of reporter antibody binding detected in the subject after initiating treatment; and

(b) increasing the dose or frequency of administration of the treatment if the amount of reporter antibody binding is the same or greater than that previously detected; or

(c) decreasing the dose or frequency of administration of the treatment or discontinuing the treatment if the amount of reporter antibody binding is less than that previously detected.

84. The method of any of claims 1-69, wherein a transthyretin-mediated amyloidosis is distinguished from amyloid light-chain (AL) amyloidosis.

85. The method of any of claims 1-54 wherein the sample is from a transgenic mouse with a transgene expressing human TTR.

86. A method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample; the method comprising:

(a) dividing a biological sample into two portions;

(b) detecting total misfolded TTR in a first portion of the biological sample by

(i) contacting the first portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody forming a sandwich complex in step (b)(i), if any, to indicate presence or absence of the misfolded TTR;

(c) detecting total multimeric misfolded TTR in a second portion of the biological sample by

(i) contacting the second portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 89-97 and a reporter antibody that

specifically binds to an epitope within residues 89-97 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody forming a sandwich complex in step (c)(i), if any, to indicate presence or absence of the multimeric misfolded TTR.

(d) calculating a ratio of the level of total multimeric misfolded TTR of (c) to the level of total misfolded TTR of (b).

87. A method of detecting misfolded transthyretin (TTR) in a biological sample, the method comprising:

(a) contacting a biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(b) detecting the reporter antibody that binds to the misfolded TTR in step (a), if any, to indicate presence or absence of the misfolded TTR.

88. The method of claim 87, wherein the biological sample is from a hereditary ATTR patient.

89. The method of claim 88, wherein the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, and S50I..

90. The method of claim 89, wherein the mutation is V30M.

91. The method of claim 89, wherein the mutation is Y114C.

92. The method of claim 89, wherein the mutation is S50I.

93. The method of claim 87, wherein the capture antibody is 18C5.

94. The method of claim 93 wherein the capture antibody is 18C5 and the reporter antibody is a polyclonal anti-TTR antibody.

95. The method of any one of claims 87-93, wherein the reporter antibody is 9D5, 14G8, 5A1, 6C1, 8C3, 7G7, AD7F6, RT24, NI-301.35G11, MFD101, MDF102, MFD103, MFD105, MFD107, MFD108, MFD109, MFD111, MFD114, or a chimeric version or humanized version thereof.

96. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 9D5, or a chimeric version or humanized version thereof.

97. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 14G8, or a chimeric version or humanized version thereof.

98. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 5A87, or a chimeric version or humanized version thereof.

99. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 6C87, or a chimeric version or humanized version thereof.

100. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 8C3, or a chimeric version or humanized version thereof.

101. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is 7G7, or a chimeric version or humanized version thereof.

102. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is AD7F6, or a chimeric version or humanized version thereof.

103. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is RT24, or a chimeric version or humanized version thereof.

104. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is NI-301.35G187, or a chimeric version or humanized version thereof.

105. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD1087, or a chimeric version or humanized version thereof.

106. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MDF102, or a chimeric version or humanized version thereof.

107. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD103, or a chimeric version or humanized version thereof.

108. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD105, or a chimeric version or humanized version thereof.

109. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD107, or a chimeric version or humanized version thereof.

110. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD108, or a chimeric version or humanized version thereof.

111. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD109, or a chimeric version or humanized version thereof.

112. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD1187, or a chimeric version or humanized version thereof.

113. The method of claim 87, wherein the capture antibody is 18C5 and the reporter antibody is MFD114, or a chimeric version or humanized version thereof.

114. The method of any one of claims 87-93, wherein the reporter antibody is an antibody that binds within residues 89-97, 118-122, 115-124, 53-63, 54-61, 36-49, 49-61, 109-121, 30-66, 70-127, 80-127, 90-127, 100-127, 110-127, or 115-127 of TTR.

115. A method of determining in vivo target engagement of a test antibody administered to a subject, which target is an epitope within residues 101-109 of misfolded transthyretin (mis-TTR) by detecting the mis-TTR remaining in a biological sample from the subject treated with the test antibody, the method comprising:

(a) contacting the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a reporter antibody that specifically binds to a different epitope within TTR from that of the capture antibody; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(b) detecting the reporter antibody forming a sandwich complex in step (a), if any, to indicate presence or absence of the misfolded TTR.

116. The method of claim 115, wherein the biological sample is from a hereditary ATTR patient.

117. The method of claim 116, wherein the biological sample is from a hereditary ATTR patient carrying a mutation selected from the group consisting of V30M, Y114C, and S50I..

118. The method of claim 117, wherein the mutation is V30M.

119. The method of claim 117, wherein the mutation is Y114C.

120. The method of claim 117, wherein the mutation is S50I.

121. The method of claim 115 or 116, wherein the capture antibody is 18C5, wherein the capture antibody and the reporter antibody have different labels.

122. The method of claim 115, wherein the reporter antibody competes for binding with the capture antibody for binding multimeric misfolded transthyretin.

123. The method of any preceding claim, wherein the reporter antibody has an electrochemiluminescent label and is detected by electrochemiluminescence.

124. The method of any preceding claim, wherein the capture antibody has a biotin label.

125. The method of any preceding claim, performed qualitatively.

126. The method of any preceding claim, performed quantitatively to indicate an absolute or relative amount of the misfolded TTR.

127. The method of any preceding claim, wherein the capture antibody is bound to a solid phase before the contacting step.

128. The method of claim 127, wherein the capture antibody is attached to the solid phase via a linker.

129. The method of claim 127, wherein the solid phase comprises at least one electrode.

130. The method of any preceding claim, further comprising: comparing a signal from the reporter antibody with a signal from the reporter antibody in a control sample containing a known amount of misfolded TTR to determine the amount of misfolded TTR in the sample.

131. The method of any preceding claim, further comprising comparing a signal from the reporter antibody from a calibration curve of signal versus amount of misfolded TTR to determine the amount of misfolded TTR in the sample.

132. The method of any preceding claim, wherein a signal from the reporter antibody is proportional to the amount of misfolded TTR in the sample.

133. The method of any preceding claim, wherein the sample is a sample from a human.

134. The method of any preceding claim, wherein the sample is a body fluid.

135. The method of any preceding claim, wherein the sample is plasma of a human.

136. The method of any preceding claim, wherein presence of misfolded TTR is used to diagnose a subject from whom the sample was obtained with a transthyretin-mediated amyloidosis.

137. The method of claim 136, wherein the transthyretin-mediated amyloidosis is a familial transthyretin amyloidosis or a sporadic wild-type transthyretin amyloidosis.

138. The method of claim 137, wherein the subject has been identified as at risk of a familial transthyretin amyloidosis based on genetic testing.

139. The method of claim 137, wherein the subject does not show symptoms of a familial transthyretin amyloidosis.

140. The method of claim 139 wherein the subject does not have polyneuropathy or cardiomyopathy.

141. The method of claim 137, wherein the familial transthyretin amyloidosis is familial amyloid cardiomyopathy (FAC), familial amyloid polyneuropathy (FAP), or central nervous system selective amyloidosis (CNSA).

142. The method of any preceding claim, wherein the biological sample is from a patient receiving treatment for a transthyretin-mediated amyloidosis.

143. A method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising

(a) comparing the amount of misfolded TTR detected by the method of claim 25 in a sample from a subject previously treated for transthyretin mediated amyloidosis with the amount of misfolded TTR detected in the subject prior to treatment or during an earlier stage of treatment; and

(b) increasing the dose or frequency of administration of the prior treatment if the amount of misfolded TTR is the same or greater than that previously detected; or

(c) decreasing the dose or frequency of administration of the prior treatment or discontinuing the prior treatment if the amount of misfolded TTR is less than that previously detected.

144. The method of claim 143 wherein the prior treatment is by intravenous administration of an anti-TTR antibody and if the amount of misfolded TTR is less than that previously detected, the prior treatment is discontinued and replaced with treatment with a TTR

stabilizer, antisense oligonucleotide based therapy, RNA interference therapy or combination therapy with doxycycline and tauroursodeoxycholic acid.

145. The method of claim 144, wherein the subject no longer receives treatment with the anti-TTR antibody.

146. The method of claim 144, wherein the TTR tetramer stabilizer is tafamidis or diflunisal.

147. The method of claim 144, wherein the TTR tetramer stabilizer is diflunisal.

148. The method of claim 144, wherein the antisense oligonucleotide based therapeutic is inotersen.

149. The method of claim 144, wherein the RNAi based therapeutic is patisiran or revusiran.

150. The method of claim 144, wherein the anti-TTR antibody is 14G8.

151. The method of claim 150, wherein the subject no longer receives treatment with the anti-TTR antibody.

152. The method of claim 150, wherein the TTR tetramer stabilizer is tafamidis or diflunisal.

153. The method of claim 150, wherein the TTR tetramer stabilizer is diflunisal.

154. The method of claim 150, wherein the antisense oligonucleotide based therapeutic is inotersen.

155. The method of claim 150, wherein the RNAi based therapeutic is patisiran or revusiran.

156. A method of adjusting treatment of a subject with a transthyretin-mediated amyloidosis, comprising

(a) comparing the amount of reporter antibody binding detected by the method of claim 46 in a sample from a subject before initiating treatment for transthyretin mediated amyloidosis with the amount of reporter antibody binding detected in the subject after initiating treatment; and

(b) increasing the dose or frequency of administration of the treatment if the amount of reporter antibody binding is the same or greater than that previously detected; or

(c) decreasing the dose or frequency of administration of the treatment or discontinuing the treatment if the amount of reporter antibody binding is less than that previously detected.

157. The method of any of claims 87-142, wherein a transthyretin-mediated amyloidosis is distinguished from amyloid light-chain (AL) amyloidosis.

158. The method of any of claim 87, wherein the sample is from a transgenic mouse with a transgene expressing human TTR.

159. A method of determining a ratio of the level of total multimeric misfolded transthyretin (TTR) to the level of total misfolded TTR in a biological sample; the method comprising:

(a) dividing a biological sample into two portions;

(b) detecting total misfolded TTR in a first portion of the biological sample by

(i) contacting the first portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 of TTR and a reporter antibody that specifically binds to a different epitope of TTR; wherein if misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody bound to the misfolded TTR in step (i), if any, to indicate presence or absence of the misfolded TTR;

(c) detecting total multimeric misfolded TTR in a second portion of the biological sample by

(i) contacting the second portion of the biological sample with a capture antibody that specifically binds to an epitope within residues 101-109 and a reporter antibody that specifically binds to an epitope within residues 101-109 of TTR; wherein if multimeric misfolded TTR is present in the sample, the capture antibody and reporter antibody bind to the multimeric misfolded TTR forming a sandwich complex; and

(ii) detecting the reporter antibody bound to the multimeric misfolded TTR in step (a), if any, to indicate presence or absence of the multimeric misfolded TTR.

(d) calculating a ratio of the level of total multimeric misfolded TTR of (c) to the level of total misfolded TTR of (b).