MONOCLONAL ANTIBODIES AND USES THEREOF

BACKGROUND OF THE INVENTION

Technical Field

The subject invention relates to monoclonal antibodies (e.g., 8F5 and 8C5) that may be used, for example, in the prevention, treatment and diagnosis of Alzheimer's Disease or other neurodegenerative disorders.

Background Information

Alzheimer's Disease (AD) is a neurodegenerative disorder characterized by a progressive loss of cognitive abilities and by characteristic neuropathological features comprising amyloid deposits, neurofibrillary tangles and neuronal loss in several regions of the brain see Hardy and Selkoe (Science 297, 353 (2002); Mattson (Nature 431, 7004 (2004). The principal constituents of amyloid deposits are amyloid beta-peptides (Aβ), with the 42 amino acid-long type (Aβ1-42) being the most prominent.

In particular, amyloid β(1-42) protein is a polypeptide having 42 amino acids which is derived from the amyloid precursor protein (APP) by proteolytic processing. This also includes, in addition to human variants, isoforms of the amyloid β(1-42) protein present in organisms other than humans, in particular, other mammals, especially rats. This protein, which tends to polymerize in an aqueous environment, may be present in very different molecular forms.

A simple correlation of the deposition of insoluble protein with the occurrence or progression of dementia disorders such as, for example, Alzheimer's disease, has proved to be unconvincing (Terry et al., Ann. Neurol. 30. 572-580 (1991); Dickson et al., Neurobiol. Aging 16, 285-298 (1995)). In contrast, the loss of synapses and cognitive

perception seems to correlate better with soluble forms of Aβ(1-42)(Lue et al., Am. J. Pathol. 155, 853-862 (1999); McLean et al., Ann. Neurol. 46, 860-866 (1999)).

Although polyclonal and monoclonal antibodies have been raised in the past against Aβ(1-42), none have proven to produce the desired therapeutic effect without also causing serious side effects in animals and/or humans. For example, passive immunization results from preclinical studies in very old APP23 mice which received a N-terminal directed anti-Aβ(1-42) antibody once weekly for 5 months indicate therapeutically relevant side effect. In particular, these mice showed an increase in number and severity of microhemorrhages compared to saline-treated mice (Pfeifer et al., Science 2002 298:1379). A similar increase in hemorrhage was recently also described for very old (>24 months) Tg2576 and PDAPP mice (Wilcock et al., J Neuroscience 2003, 23: 3745-51; Racke et al., J Neuroscience 2005, 25:629-636). In both strains, injection of anti-Aβ(1-42) resulted in a significant increase of microhemorrhages. Thus, a tremendous therapeutic need exists for the development of biologics that prevent or slow down the progression of the disease without inducing negative and potentially lethal effects on the human body. Such need is particularly evident in view of the increasing longevity of the general population and, with this increase, an associated rise in the number of patents annually diagnosed with Alzheimer's Disease. Further, such antibodies will allow for proper diagnosis of Alzheimer's Disease in a patient experiencing symptoms thereof, a diagnosis which can only be confirmed upon autopsy at the present time. Additionally, the antibodies will allow for the elucidation of the biological properties of the proteins and other biological factors responsible for this debilitating disease.

All patents and publications referred to herein are hereby incorporated in their entirety by reference.

SUMMARY OF THE INVENTION

The present invention includes an isolated antibody that binds with greater specificity to an amyloid beta (Aβ) protein globulomer than to an amyloid beta protein monomer. Thus, preferential binding is observed. The antibody may be, for example, a monoclonal antibody such as 8F5 or 8C5. The ratio of binding specificity to the globulomer versus the monomer is at least 1.4. In particular, the ratio is preferably at least about 1.4 to at least about 16.9. (A ratio of 1.0-17.5 including the endpoints) is also considered to fall within the scope of the present invention as well as decimal percentages thereof. For example, 1.1, 1.2, 1.3, …, 2.0, 2.1, 2.2…,17.1, 17.2, 17.3, 17.4, 17.5 as well as all full integers in between and percentages thereof are considered to fall within the scope of the present invention.) The amyloid beta protein monomer may be, for example, Aβ(1-42) monomer or Aβ(1-40) monomer.

In one aspect, there is provided a humanized monoclonal antibody comprising a variable heavy and light chain, wherein:

the three CDRs of said variable heavy chain are SEQ ID NO:5, SEQ ID NO:6 and SEQ ID NO:7, and

the three CDRs of said variable light chain are SEQ ID NO:8, SEQ ID NO:9 and SEQ ID NO:10,

wherein the antibody binds with greater specificity to an amyloid beta protein globulomer than to an amyloid beta protein monomer.

In one aspect, there is provided a pharmaceutical composition comprising an antibody as defined above.

In one aspect, there is provided a vaccine comprising an antibody as defined above and a pharmaceutically acceptable adjuvant.

In one aspect, there is provided a method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with an antibody as defined above for a time and under conditions sufficient for formation of antigen/antibody complexes; and

(b) detecting presence of said antigen/antibody complexes in said sample, presence of said complexes indicating a diagnosis of Alzheimer's Disease in said patient.

In one aspect, there is provided a method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with an antigen that is an amyloid beta (Aβ) protein globulomer for a time and under conditions sufficient for the formation of antigen/antibody complexes;

(b) adding a conjugate to the resulting antibody/antigen complexes for a time and under conditions sufficient to allow said conjugate to bind to the bound antibody, wherein said conjugate comprises an antibody as defined above; and

(c) detecting presence of said antigen/antibody complexes in said sample, presence of said complexes indicating a diagnosis of Alzheimer's Disease in said patient.

In one aspect, there is provided a method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with anti-antibody, wherein said anti-antibody is specific for said antibody as defined above for a time and under conditions sufficient to allow for formation of anti-antibody/antibody complexes, said complexes containing antibody present in said biological sample;

(b) adding a conjugate to resulting anti-antibody/antibody complexes for a time and under conditions sufficient to allow said conjugate to bind to bound antibody, wherein said conjugate comprises an antigen, which binds to a signal generating compound capable of generating a detectable signal; and

(c) detecting a signal generated by said signal generating compound, said signal indicating a diagnosis of Alzheimer's Disease in said patient.

In one aspect, there is provided a method of identifying compounds suitable for active immunization of a patient predicted to develop Alzheimer's Disease comprising the steps of:

(a) exposing one or more compounds of interest to an antibody as defined above for a time and under conditions sufficient for said one or more compounds to bind to said antibody as defined above; and

(b) identifying those compounds which bind to said antibody as defined above, said identified compounds to be used in active immunization in a patient predicted to develop Alzheimer's Disease.

In one aspect, there is provided a kit comprising:

(a) an antibody as defined above and

(b) a conjugate comprising a second Aβ protein globulomer-specific antibody attached to a signal-generating compound capable of generating a detectable signal, wherein said second antibody of said conjugate is different from said antibody as defined above.

In one aspect, there is provided a kit comprising:

(a) an anti-antibody to an antibody as defined above and

(b) a conjugate comprising an Aβ protein globulomer attached to a signal-generating compound capable of generating a detectable signal.

Further, the present invention also encompasses a monoclonal antibody (referred to herein as "8F5") produced by a hybridoma having American Type Culture Collection designation number PTA-7238 as well as the hybridoma that produces this monoclonal antibody (i.e., 8F5). Also, the present invention includes a monoclonal antibody (referred to herein as "8C5") produced by a hybridoma having American Type Culture Collection designation number PTA-7407 as well as the hybridoma that produces this monoclonal antibody (i.e., 8C5).

Additionally, the present invention includes a monoclonal antibody comprising a variable heavy chain encoded by SEQ ID NO:1. This antibody may be murine, human or humanized.

Further, the present invention includes a monoclonal antibody comprising a variable light chain encoded by SEQ ID NO:2. This antibody may also be murine, human or humanized. The antibody may further comprise a variable light heavy chain encoded by SEQ ID NO:1 and may be human or humanized.

Moreover, the present invention includes a monoclonal antibody comprising SEQ ID NO:3. The antibody may be murine, human or humanized.

Further, the present invention encompasses a monoclonal antibody comprising SEQ ID NO:4. This antibody may be murine, human or humanized. This antibody may further comprise SEQ ID NO:3 and may be murine, human or humanized.

Additionally, the present invention includes a monoclonal antibody comprising a variable heavy chain encoded by SEQ ID NO:11. This antibody may be murine, human or humanized.

Further, the present invention includes a monoclonal antibody comprising a variable light chain encoded by SEQ ID NO:12. This antibody may also be murine, human or humanized. The antibody may further comprise a variable heavy chain encoded by SEQ ID NO:11 and may be human or humanized.

Moreover, the present invention includes a monoclonal antibody comprising SEQ ID NO:19. The antibody may be murine, human or humanized.

Further, the present invention encompasses a monoclonal antibody comprising SEQ ID NO:20. This antibody may be murine, human or humanized. This antibody may further comprise SEQ ID NO:19 and may be murine, human or humanized.

The present invention also includes an isolated antibody which binds with greater specificity to an amyloid beta protein globulomer than to an amyloid beta protein fibril. This antibody may be, for example, monoclonal and may be the monoclonal antibody produced by the hybridoma having American Type Culture Collection designation number PTA-7243 or the

hybridoma having American Type Culture Collection PTA-7407. The hybridomas producing these monoclonal antibodies also fall within the scope of the present invention.

Further, the present invention includes an antibody in which at least one of the complementarity determining regions (CDRs) of the variable heavy chain is selected from the group consisting of SEQ ID NO:5, SEQ ID NO:6 and SEQ ID NO:7.

Moreover, the present invention also includes an antibody in which at least one of the CDRs of the variable light chain is selected from the group consisting of SEQ ID NO:8, SEQ ID NO:9 and SEQ ID NO:10. This antibody may further comprise at least one CDR of the variable heavy chain selected from the group consisting of SEQ ID NO:5, SEQ ID NO:6 and SEQ ID NO:7.

The present invention also includes an antibody in which at least one of the CDRs of the variable heavy chain is selected from the group consisting of SEQ ID NO:13, SEQ ID NO:14 and SEQ ID NO:15.

Further, the present invention also encompasses an antibody in which at least one of the CDRs of the variable light chain is selected from the group consisting of SEQ ID NO:16, SEQ ID NO:17 and SEQ ID NO:18. This antibody may further comprises at least one CDR of the variable heavy chain selected from the group consisting of SEQ ID NO:13, SEQ ID NO:14 and SEQ ID NO:15.

Additionally, the present invention encompasses a method of treating or preventing Alzheimer's Disease in a patient in need of the treatment or prevention. This method comprises administering any one or more of the isolated antibodies described above to the patient in an amount sufficient to effect the treatment or prevention.

The isolated antibody may be administered, for example, *via* a route selected from the group consisting of intramuscular

administration, intravenous administration and subcutaneous administration.

The present invention also includes a method of diagnosing Alzheimer's Disease in a patient suspected of having this disease. This method comprises the steps of: 1) isolating a biological sample from the patient; 2) contacting the biological sample with at least one of the antibodies described above for a time and under conditions sufficient for formation of antigen/antibody complexes; and 3) detecting presence of the antigen/antibody complexes in said sample, presence of the complexes indicating a diagnosis of Alzheimer's Disease in the patient. The antigen may be, for example, a globulomer or a portion or fragment thereof which has the same functional properties as the full globulomer (e.g., binding activity).

Further, the present invention includes another method of diagnosing Alzheimer's Disease in a patient suspected of having this disease. This method comprises the steps of: 1) isolating a biological sample from the patient; 2) contacting the biological sample with an antigen for a time and under conditions sufficient for the formation of antibody/antigen complexes; 3) adding a conjugate to the resulting antibody/antigen complexes for a time and under conditions sufficient to allow the conjugate to bind to the bound antibody, wherein the conjugate comprises one of the antibodies described above, attached to a signal generating compound capable of generating a detectable signal; and 4) detecting the presence of an antibody which may be present in the biological sample, by detecting a signal generated by the signal generating compound, the signal indicating a diagnosis of Alzheimer's Disease in the patient. The antigen may be a globulomer or a portion or fragment thereof having the same

functional properties as the full globulomer (e.g., binding activity).

The present invention includes an additional method of diagnosing Alzheimer's Disease in a patient suspected of having Alzheimer's Disease. This method comprises the steps of: 1) isolating a biological sample from the patient; 2) contacting the biological sample with anti-antibody, wherein the anti-antibody is specific for one of the antibodies described above, for a time and under conditions sufficient to allow for formation of anti-antibody/antibody complexes, the complexes containing antibody present in the biological sample; 2) adding a conjugate to the resulting anti-antibody/antibody complexes for a time and under conditions sufficient to allow the conjugate to bind to bound antibody, wherein the conjugate comprises an antigen, which binds to a signal generating compound capable of generating a detectable signal; and 3) detecting a signal generated by the signal generating compound, the signal indicating a diagnosis of Alzheimer's Disease in the patient.

Further, the present invention includes a composition comprising any one or more of the antibodies described above (e.g., 8F5 and 8C5).

The present invention includes another method of preventing or treating Alzheimer's Disease in a patient in need of such prevention or treatment. This method comprises the step of administering the composition described directly above to the patient in an amount sufficient to effect the prevention or treatment.

Additionally, the present invention encompasses a vaccine comprising at least one of the antibodies described above and a pharmaceutically acceptable adjuvant.

Moreover, the present invention includes a further method of preventing or treating Alzheimer's Disease in a patient in

need of such prevention or treatment. This method comprises the step of administering the vaccine noted above to the patient in an amount sufficient to effect the prevention or treatment.

Further, the present invention encompasses a method of identifying compounds suitable for active immunization of a patient predicted to develop Alzheimer's Disease. This method comprises: 1) exposing one or more compounds of interest to one or more of the antibodies described above for a time and under conditions sufficient for the one or more compounds to bind to the antibody or antibodies; 2) identifying those compounds which bind to the antibody or antibodies, the identified compounds to be used in active immunization in a patient predicted to develop Alzheimer's Disease.

Also, the present invention includes a kit comprising: a) at least one of the isolated antibodies described above and b) a conjugate comprising an antibody attached to a signal-generating compound, wherein the antibody of the conjugate is different from the isolated antibody. The kit may also include a package insert with instructions as to how the components of the kit are to be utilized.

The present invention also encompasses a kit comprising: a) an anti-antibody to one of the antibodies described above and b) a conjugate comprising an antigen attached to a signal-generating compound. The antigen may be a globulomer or a fragment or portion thereof having the same functional characteristics as the globulomer (e.g., binding activity). Again, the kit may also include a package insert with instructions as to how the components of the kit are to be utilized.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the selectivity of 8F5 for globulomers versus Aß(1-42) monomers, Aß(1-40) and sAPP. Selectivity factors for 8F5 can be calculated as ratios between EC50 values (versus Aß(1-42) monomer in HFIP: 555.8/90.74 = 6.1; versus Aß(1-42) monomer in NH_4OH: 1007/90.74 = 11.1; versus Aß(1-40) monomer: 667.8/90.74 = 7.4 versus sAPP: >100)

Figure 2 illustrates SDS-PAGE analysis of fibril bound heavy and light chain antibodies (lanes 4, 6, 8) and corresponding non-bound free fractions (lanes 3, 5, 7) in the supernatants.

Figure 3 illustrates Aß42 and Aß40 content in CSF samples from patients with Mild Cognitive Impairment (MCI, left) or Alzheimer's disease (AD, right). In both groups, it can be observed that 8F5 picks up a higher proportion of Aß(1-42) and less or an equal amount of Aß(1-40) if compared to a standard antibody 6E10 or compared to direct sample analysis with the same ELISAs.

Figure 4 illustrates novel object recognition index as time spent with unknown versus familiar object in three groups of APP transgenic mice (i.e., 6G1, 8F5, PBS) and one group of non-transgenic litter mates (wild type). The animals (number given below columns) were immunized with monoclonal antibodies 6G1 or 8F5 or treated with vehicle (i.e., phosphate-buffered saline; PBS, and wild type) by once weekly intraperitoneal injection for three weeks. On the day of the last injection, a novel object recognition task was performed. The difference between PBS and wild type groups indicated a cognitive deficit of APP transgenic mice in this paradigm. PBS-injected mice performed at chance level (i.e., not significantly different from 50) while all other mice showed object recognition (t-test; stars). When the performance of antibody-treated APP

transgenic mice was compared with control groups, a significant difference was found versus PBS-treated but not versus wild-type mice (ANOVA with post-hoc t-test; circles) indicating that antibody treatment reversed the cognitive deficit in these APP transgenic mice.

Figure 5(A) illustrates the DNA sequence (SEQ ID NO:1) of the variable heavy chain encoding the monoclonal antibody referred to herein as "8F5", and Figure 5(B) illustrates the DNA sequence (SEQ ID NO:2) of the variable light chain encoding the monoclonal antibody 8F5. (Complementarity determining regions (CDRs) are underlined in each sequence; see also Figure 6.)

Figure 6(A) illustrates the amino acid sequence (SEQ ID NO:3) of the variable heavy chain of monoclonal antibody 8F5, and Figure 6(B) illustrates the amino acid sequence (SEQ ID NO:4) of the variable light chain of monoclonal antibody 8F5. One CDR of the variable heavy chain is represented by the amino acid sequence SYGMS (SEQ ID NO:5). Another CDR of the variable heavy chain is represented by the amino acid sequence ASINSNGGSTYYPDSVKG (SEQ ID NO:6), and another CDR of the variable heavy chain is represented by the amino acid sequence SGDY (SEQ ID NO:7). One CDR of the variable light chain is represented by the amino acid sequence RSSQSLVYSNGDTYLH (SEQ ID NO:8). Another CDR of the variable light chain is represented by the amino acid sequence KVSNRFS (SEQ ID NO:9), and another CDR of the variable light chain is represented by the amino acid sequence SQSTHVPWT (SEQ ID NO:10). All of the above-described CDRs are underlined in Figure 6(A) and 6(B).

Figure 7 shows the binding of antibodies, at different concentrations, to transversal sections of the neocortices of Alzheimer's disease (AD) patients or old APP transgenic mice. In particular, Figure 7(A) illustrates verification of amyloid deposits by Congo Red staining as plaques in brain tissue and

as cerebral amyloid angiopathy (CAA) in brain vessels in the APP transgenic mouse line Tg2576 and in an AD patient (RZ55). Figure 7(B) illustrates that the staining of parenchymal deposits of Aβ (amyloid plaques) in an AD patient (RZ16) occurs only with 6G1 and the commercially available antibody 6E10 while 8F5 and 8C5 show considerably weaker staining. Figure 7(C) illustrates that the strong staining of parenchymal deposits of Aβ (amyloid plaques) in TG2576 mice occurs only with 6G1 and the commercially available antibody 6E10 while 8F5 and 8C5 show considerably weaker staining. Figures 7(D)-(G) illustrate the quantification of the analysis of Aβ plaque staining in the histological images using image analysis. Optical density values (0% = no staining) were calculated from the greyscale values of plaques subtracted by greyscale values of background tissue. (Fig. (D)= binding of 0.7 μg/ml antibody in Tg2576 mice; Fig. (E)= binding of 0.07-0.7 μg/ml antibody in APP/L mice; Fig. (F)= binding of 0.7 μg/ml antibody in an AD patient (RZ55); and Fig. (G)= binding of 0.07-0.7 μg/ml antibody in an AD patient (RZ16)) The differences between staining of the commercially available antibodies 6E10 (starts) and 4G8 (circles) and antibodies 6G1, 8C5 and 8F5 (one asterisk/circle: $p < 0.05$, two asterisks/circles: $p < 0.01$, and three asterisks/circles: $p<0.001$ versus control; post-hoc Bonferroni's t-test after ANOVA with $p<0.001$) were statistically evaluated (Fig. (D) and Fig. (E)). In Figs. (E) and (G), the antibodies 8C5 and 8F5 always showed significantly less staining than the commercially available antibodies 6E10 and 4G8 ($p<0.05$ in post-hoc t-test after $p<0.001$ in ANOVA). Figure (H) illustrates that the strong staining of vascular deposits of Aβ (arrows) occurs only with

6G1 and the commercially available antibody 6E10 while staining with 8F5 or 8C5 was much weaker. A qualitatively similar situation was found in Tg2576 mice (not shown here).

Figure 8 illustrates the selectivity of 8C5 for globulomers versus Aß(1-42) monomers, Aß(1-40) and sAPP. Selectivity factors for 8C5 can be calculated as ratios between EC50 values (versus Aß(1-42) monomer in HFIP: 2346/568.2 = 4.1; versus Aß(1-42) monomer in NH_4OH: >100; versus Aß(1-40) monomer: >100; versus sAPP: >100)

Figure 9(A) illustrates the nucleotide sequence (SEQ ID NO:11) encoding the heavy chain of 8C5 and Figure 9(B) illustrates the nucleotide sequence (SEQ ID NO:12) encoding the light chain of 8C5. The nucleotide sequences encoding the corresponding CDRs, noted in Figure 10(A) and 10(B), are underlined.

Figure 10(B) illustrates the amino acid sequence (SEQ ID NO:19) of the variable heavy chain of monoclonal antibody 8C5, and Figure 10(B) illustrates the amino acid sequence (SEQ ID NO:20) of the variable light chain of monoclonal antibody 8F5. One CDR of the variable heavy chain is represented by the amino acid sequence SYGMS (SEQ ID NO:13). Another CDR of the variable heavy chain is represented by the amino acid sequence SIKNNGGSTYYPDSLKG (SEQ ID NO:14), and another CDR of the variable heavy chain is represented by the amino acid sequence SGDY (SEQ ID NO:15). One CDR of the variable light chain is represented by the amino acid sequence RSSQSLVHSNGDTFLH (SEQ ID NO:16). Another CDR of the variable light chain is represented by the amino acid sequence KVSNRFS (SEQ ID NO:17), and another CDR of the variable light chain is represented by

the amino acid sequence SQSIHVPWT (SEQ ID NO:18). All of the above-described CDRs are underlined in Figure 10(A) and 10(B).

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a monoclonal antibody, referred to herein as "8F5" as well as other related antibodies (e.g., 8C5). These antibodies may be used, for example, in the diagnosis, prevention and treatment of Alzheimer's Diseases and other neurodegenerative disorders.

Monoclonal antibody 8F5 as well as monoclonal antibody 8C5 have many interesting properties which allow them to be extremely interesting therapeutic candidates as well as extremely useful diagnostic candidates. For example, monoclonal antibodies 8F5 and 8C5 have preferential binding for Aβ(1-42) globulomers as compared with monomers or fibrils.

The term "Aβ(X-Y)" herein refers to the amino acid sequence from amino acid position X to amino acid position Y of the human amyloid β protein including both X and Y and, in particular, refers to the amino acid sequence from amino acid position X to amino acid position Y of the amino acid sequence DAEFRHDSGY EVHHQKLVFF AEDVGSNKGA IIGLMVGGVV IA or any of its naturally occurring variants, in particular, those with at least one mutation selected from the group consisting of A2T, H6R, D7N, A21G ("Flemish"), E22G ("Arctic"), E22Q ("Dutch"), E22K ("Italian"), D23N ("Iowa"), A42T and A42V wherein the numbers are relative to the start position of the Aβ peptide, including both position X and position Y or a sequence with up to three additional amino acid substitutions none of which may prevent globulomer formation. An "additional" amino acid substitution is defined herein as any deviation from the canonical sequence that is not found in nature.

More specifically, the term "Aβ(1-42)" herein refers to the amino acid sequence from amino acid position 1 to amino acid position 42 of the human amyloid β protein including both 1 and 42 and, in particular, refers to the amino acid sequence from amino acid position 1 to amino acid position 42 of the amino acid sequence DAEFRHDSGY EVHHQKLVFF AEDVGSNKGA IIGLMVGGVV IA (corresponding to amino acid positions 1 to 42) or any of its naturally occurring variants. Such variants may be, for example, those with at least one mutation selected from the group consisting of A2T, H6R, D7N, A21G ("Flemish"), E22G ("Arctic"), E22Q ("Dutch"), E22K ("Italian"), D23N ("Iowa"), A42T and A42V wherein the numbers are relative to the start of the Aβ peptide, including both 1 and 42 or a sequence with up to three additional amino acid substitutions none of which may prevent globulomer formation. Likewise, the term "Aβ(1-40)" here refers to the amino acid sequence from amino acid position 1 to amino acid position 40 of the human amyloid β protein including both 1 and 40 and refers, in particular, to the amino acid sequence from amino acid position 1 to amino acid position 40 of the amino acid sequence DAEFRHDSGY EVHHQKLVFF AEDVGSNKGA IIGLMVGGVV or any of its naturally occurring variants. Such variants include, for example, those with at least one mutation selected from the group consisting of A2T, H6R, D7N, A21G ("Flemish"), E22G ("Arctic"), E22Q ("Dutch"), E22K ("Italian"), and D23N ("Iowa") wherein the numbers are relative to the start position of the Aβ peptide, including both 1 and 40 or a sequence with up to three additional amino acid substitutions none of which may prevent globulomer formation.

The term "Aβ(X-Y) globulomer" (also known as "Aβ(X-Y) globular oligomer") herein refers to a soluble, globular, non-

covalent association of Aβ (X-Y) peptides, as defined above, possessing homogeneity and distinct physical characteristics. The Aβ(X-Y) globulomers are stable, non-fibrillar, oligomeric assemblies of Aβ (X-Y) peptides which are obtainable by incubation with anionic detergents. In contrast to monomer and fibrils, these globulomers are characterized by defined assembly numbers of subunits (e.g., early assembly forms, n=3-6, oligomers A", and late assembly forms, n=12- 14, " oligomers B", as described in PCT International Application Publication No. WO 04/067561). The globulomers have a 3-dimensional globular type structure ("molten globule", see Barghorn et al., 2005, J Neurochem, 95, 834-847). They may be further characterized by one or more of the following features:

- cleavability of N-terminal amino acids X-23 with promiscuous proteases (such as thermolysin or endoproteinase GluC) yielding truncated forms Aß(X-Y) globulomers;
- non-accessibility of C-terminal amino acids 24-Y with promiscuous proteases and antibodies; and
- truncated forms of these Aß(X-Y) globulomers maintain the 3-dimensional core structure of the globulomers with a better accessibility of the core epitope Aß(20-Y) in its globulomer conformation.

According to the invention and, in particular, for the purpose of assessing the binding affinities of the antibodies of the present invention, the term "Aβ(X-Y) globulomer" herein refers to a product which is obtainable by a process as described in International Application Publication No. WO 04/067561, which is incorporated herein in its entirety by reference. The process comprises unfolding a natural, recombinant or synthetic Aβ (X-Y) peptide or a derivative

thereof; exposing the at least partially unfolded Aβ (X-Y) peptide or derivative thereof to a detergent, reducing the detergent action and continuing incubation.

For the purpose of unfolding the peptide, hydrogen bond-breaking agents such as, for example, hexafluoroisopropanol (HFIP) may be allowed to act on the protein. Times of action of a few minutes, for example about 10 to 60 minutes, are sufficient when the temperature of action is from about 20 to 50°C and, in particular, about 35 to 40°C. Subsequent dissolution of the residue evaporated to dryness, preferably in concentrated form, in suitable organic solvents miscible with aqueous buffers such as, for example, dimethyl sulfoxide (DMSO), results in a suspension of the at least partially unfolded peptide or derivative thereof which can be used subsequently. If required, the stock suspension may be stored at low temperature, for example, at about -20°C for an interim period.

Alternatively, the peptide or the derivative thereof may be taken up in slightly acidic, preferably aqueous, solution, for example, a solution of about 10 mM aqueous HCl. After an incubation time of approximately a few minutes, insoluble components are removed by centrifugation. A few minutes at 10,000 g is expedient. These method steps are preferably carried out at room temperature, i.e., a temperature in the range of from 20 to 30°C. The supernatant obtained after centrifugation contains the Aβ (X-Y) peptide or a derivative thereof and may be stored at low temperature, for example at about -20°C, for an interim period.

The following exposure to a detergent relates to oligomerization of the peptide or the derivative thereof to give the intermediate type of oligomers (in International Application Publication No. WO 04/067561 referred to as

oligomers A). For this purpose, a detergent is allowed to act on the, optionally, at least partially unfolded peptide or derivative thereof until sufficient intermediate oligomer has been produced. Preference is given to using ionic detergents, in particular, anionic detergents.

According to a particular embodiment, a detergent of the formula (I):

R-X,

is used, in which the radical "R" is unbranched or branched alkyl having from 6 to 20 and preferably 10 to 14 carbon atoms or unbranched or branched alkenyl having from 6 to 20 and preferably 10 to 14 carbon atoms, and the radical "X" is an acidic group or salt thereof with X being preferably selected from among $-COO^-M^+$, $-SO_3^-M^+$ and is, most preferably, $-OSO_3^-M^+$, and M^+ is a hydrogen cation or an inorganic or organic cation preferably selected from alkali metal cations, alkaline earth metal cations and ammonium cations. Most advantageous are detergents of the formula (I) in which R is an unbranched alkyl of which alk-1-yl radicals must be mentioned, in particular. Particular preference is given to sodium dodecyl sulfate (SDS). Lauric acid and oleic acid can also be used advantageously. The sodium salt of the detergent lauroylsarcosin (also known as sarkosyl NL-30 or Gardol®) is also particularly advantageous.

The time of detergent action, in particular, depends on whether, and if yes, to what extent the peptide or derivative thereof subjected to oligomerization has unfolded. If, according to the unfolding step, the peptide or derivative thereof has been treated beforehand with a hydrogen bond-breaking agent (i.e., in particular with hexafluoroisopropanol), times of action in the range of a few hours, advantageously from about 1 to 20 and, in particular, from about 2 to 10 hours, are sufficient when the temperature

of action is about 20 to 50°C and, in particular, from about 35 to 40°C. If a less unfolded or an essentially not unfolded peptide or derivative thereof is the starting point, correspondingly longer times of action are expedient. If the peptide or derivative thereof has been pretreated, for example, according to the procedure indicated above as an alternative to the HFIP treatment or said peptide or derivative thereof is directly subjected to oligomerization, times of action in the range from about 5 to 30 hours and, in particular, from about 10 to 20 hours are sufficient when the temperature of action is from about 20 to 50°C and, in particular, from about 35 to 40°C. After incubation, insoluble components are advantageously removed by centrifugation. A few minutes at 10,000 g is expedient.

The detergent concentration to be chosen depends on the detergent used. If SDS is used, a concentration in the range from 0.01 to 1% by weight, preferably, from 0.05 to 0.5% by weight, for example, of about 0.2% by weight, proves expedient. If lauric acid or oleic acid is used, somewhat higher concentrations are expedient, for example, in a range from 0.05 to 2% by weight, preferably, from 0.1 to 0.5% by weight, for example, of about 0.5% by weight.
The detergent action should take place at a salt concentration approximately in the physiological range. Thus, in particular NaCl concentrations in the range from 50 to 500 mM, preferably, from 100 to 200 mM and, more particularly, at about 140 mM are expedient.

The subsequent reduction of the detergent action and continuation of incubation relates to further oligomerization to give the Aβ(X-Y) globulomer of the invention (in International Application Publication No. WO 04/067561 referred to as oligomer B). Since the composition obtained from the preceding step regularly contains detergent and a

salt concentration in the physiological range, it is then expedient to reduce detergent action and, preferably, also salt concentration. This may be carried out by reducing the concentration of detergent and salt, for example, by diluting expediently with water or a buffer of lower salt concentration, for example, Tris-HCl, pH 7.3. Dilution factors in the range from about 2 to 10, advantageously, in the range from about 3 to 8 and, in particular, of about 4, have proved suitable. The reduction in detergent action may also be achieved by adding substances which can neutralize this detergent action. Examples of these include substances capable of complexing the detergents, like substances capable of stabilizing cells in the course of purification and extraction measures, for example, particular EO/PO block copolymers, in particular, the block copolymer under the trade name Pluronic® F 68. Alkoxylated and, in particular, ethoxylated alkyl phenols such as the ethoxylated t-octylphenols of the Triton® X series, in particular, Triton® X100, 3-(3-cholamidopropyldimethylammonio)-1-propanesulfonate (CHAPS®) or alkoxylated and, in particular, ethoxylated sorbitan fatty esters such as those of the Tween® series, in particular, Tween® 20, in concentration ranges around or above the particular critical micelle concentration, may be equally used.

Subsequently, the solution is incubated until sufficient Aβ(X-Y) globulomer has been produced. Times of action in the range of several hours, preferably, in the range from about 10 to 30 hours and, in particular, in the range from about 15 to 25 hours, are sufficient when the temperature of action is about 20 to 50°C and, in particular, about 35 to 40°C. The solution may then be concentrated and possible residues may be removed by centrifugation. Again, a few minutes at 10,000 g proves expedient. The supernatant obtained after

centrifugation contains an Aβ(X-Y) globulomer as described herein.

An Aβ(X-Y) globulomer can be finally recovered, e.g. by ultrafiltration, dialysis, precipitation or centrifugation. It is further preferred if electrophoretic separation of the Aβ(X-Y) globulomers under denaturing conditions, e.g. by SDS-PAGE, produces a double band (e.g., with an apparent molecular weight of 38/48 kDa for Aβ (1-42)) and especially preferred if upon glutardialdehyde treatment of the oligomers, before separation, these two bands are merged into one. It is also preferred if size exclusion chromatography of the globulomers results in a single peak (e.g., corresponding to a molecular weight of approximately 60 kDa for Aβ (1-42)). Starting from Aβ(1-42) peptide, the process is, in particular, suitable for obtaining Aβ(1-42) globulomers
Preferably, the globulomer shows affinity to neuronal cells and also exhibits neuromodulating effects.
A "neuromodulating effect" is defined as a long-lasting inhibitory effect of a neuron leading to a dysfunction of the neuron with respect to neuronal plasticity.

According to another aspect of the invention, the term "Aβ(X-Y) globulomer" herein refers to a globulomer consisting essentially of Aβ(X-Y) subunits, wherein it is preferred if, on average, at least 11 of 12 subunits are of the Aβ(X-Y) type, more preferred, if less than 10% of the globulomers comprise any non-Aβ(X-Y) peptides and, most preferred, if the content of non-Aβ(X-Y) peptides in the preparation is below the detection threshold. More specifically, the term "Aβ(1-42) globulomer" herein refers to a globulomer comprising Aβ(1-42) units as defined above; the term "Aβ(12-42) globulomer" herein refers to a globulomer comprising Aβ(12-42) units as defined above; and the term "Aβ(20-42) globulomer" herein

refers to a globulomer comprising Aβ(20-42) units as defined above.

The term "cross-linked Aβ(X-Y) globulomer" herein refers to a molecule obtainable from an Aβ(X-Y) globulomer as described above by cross-linking, preferably, chemically cross-linking, more preferably, aldehyde cross-linking and, most preferably, glutardialdehyde cross-linking of the constituent units of the globulomer. In another aspect of the invention, a cross-linked globulomer is essentially a globulomer in which the units are at least partially joined by covalent bonds, rather than being held together by non-covalent interactions only.

The term "Aβ(X-Y) globulomer derivative" herein refers, in particular, to a globulomer that is labelled by being covalently linked to a group that facilitates detection, preferably, a fluorophore, e.g., fluorescein isothiocyanate, phycoerythrin, Aequorea victoria fluorescent protein, Dictyosoma fluorescent protein or any combination or fluorescence-active derivatives thereof; a chromophore; a chemoluminophore, e.g., luciferase, preferably Photinus pyralis luciferase, Vibrio fischeri luciferase, or any combination or chemoluminescence-active derivatives thereof; an enzymatically active group, e.g., peroxidase such as horseradish peroxidase, or an enzymatically active derivative thereof; an electron-dense group, e.g., a heavy metal containing group such as a gold containing group; a hapten, e.g., a phenol derived hapten; a strongly antigenic structure, e.g., peptide sequence predicted to be antigenic such as by the algorithm of Kolaskar and Tongaonkar; an aptamer for another molecule; a chelating group, e.g., hexahistidinyl; a natural or nature-derived protein structure mediating further specific protein-protein interactions, e.g., a member of the fos/jun pair; a magnetic group, e.g., a ferromagnetic group;

or a radioactive group such as a group comprising ^{1}H, ^{14}C, ^{32}P, ^{35}S or ^{125}I or any combination thereof; or to a globulomer flagged by being covalently or by non-covalently linked by high-affinity interaction, preferably, covalently linked to a group that facilitates inactivation, sequestration, degradation and/or precipitation, preferably, flagged with a group that promotes *in vivo* degradation, more preferably, with ubiquitin, where it is particularly preferred if this flagged oligomer is assembled *in vivo*; or to a globulomer modified by any combination of the above. Such labelling and flagging groups and methods for attaching them to proteins are known in the art. Labelling and/or flagging may be performed before, during or after globulomerization. In another aspect of the invention, a globulomer derivative is a molecule obtainable from a globulomer by a labelling and/or flagging reaction. Correspondingly, the term "Aβ(X-Y) monomer derivative" herein refers, in particular, to an Aβ monomer that is labelled or flagged as described for the globulomer.

The term "greater affinity" herein refers to a degree of interaction where the equilibrium between unbound antibody and unbound globulomer, on the one hand, and antibody-globulomer complex, on the other, is further in favor of the antibody-globulomer complex. Likewise, the term "smaller affinity" herein refers to a degree of interaction where the equilibrium between unbound antibody and unbound globulomer, on the one hand, and antibody-globulomer complex, on the other, is further in favor of the unbound antibody and unbound globulomer.

The term "Aβ(X-Y) monomer" herein refers to the isolated form of the Aβ(X-Y) peptide, preferably, a form of the Aβ(X-Y) peptide which is not engaged in essentially non-covalent interactions with other Aβ peptides. Practically, the Aβ(X-Y) monomer is usually provided in the form of an aqueous

solution. Preferably, the aqueous monomer solution contains 0.05% to 0.2%, more preferably, about 0.1% NaOH when used, for instance, for determining the binding affinity of the antibody of the present invention. In another preferable situation, the aqueous monomer solution contains 0.05% to 0.2%, more preferably, about 0.1% NaOH. When used, it may be expedient to dilute the solution in an appropriate manner. Further, it is usually expedient to use the solution within 2 hours, in particular, within 1 hour, and, especially, within 30 minutes after its preparation.

The term "fibril" herein refers to a molecular structure that comprises assemblies of non-covalently associated, individual Aβ(X-Y) peptides which show fibrillary structure under the electron microscope, which bind Congo red, exhibit birefringence under polarized light and whose X-ray diffraction pattern is a cross-β structure. The fibril may also be defined as a molecular structure obtainable by a process that comprises the self-induced polymeric aggregation of a suitable Aβ peptide in the absence of detergents, e.g., in 0.1 M HCl, leading to the formation of aggregates of more than 24, preferably, more than 100 units. This process is well known in the art. Expediently, Aβ(X-Y) fibril is used in the form of an aqueous solution. In a particularly preferred embodiment of the invention, the aqueous fibril solution is made by dissolving the Aβ peptide in 0.1% NH_4OH, diluting it 1:4 with 20 mM NaH_2PO_4, 140 mM NaCl, pH 7.4, followed by readjusting the pH to 7.4, incubating the solution at 37 °C for 20 h, followed by centrifugation at 10000 g for 10 min and resuspension in 20 mM NaH_2PO_4, 140 mM NaCl, pH 7.4.

The term "Aβ(X-Y) fibril" herein refers to a fibril comprising Aβ(X-Y) subunits where it is preferred if, on average, at least 90% of the subunits are of the Aβ(X-Y) type,

more preferred, if at least 98% of the subunits are of the Aβ(X-Y) type and, most preferred, if the content of non-Aβ(X-Y) peptides is below the detection threshold.

Turning back to 8F5, as evidenced by Figure 1, as well as 8C5 (Figure 8), Aβ(1-42) globulomer-specific antibodies monoclonal antibodies 8F5 and 8C5 recognize predominantly Aβ(1-42) globulomer forms and not standard preparations of Aβ(1-40) or Aβ(1-42) monomers including aggregated Aβ(1-42) in contrast to nonspecific antibodies 6G1 and 6E10. In particular, 8F5 detects Aβ(1-42) globulomers only by native PAGE-western blot and not by SDS-PAGE Western blot analysis indicating binding to a more complex detergent-dissociable intersubunit epitope in the core Aβ(1-42) globulomer structure. An intersubunit epitope is defined as a complex non-linear through space epitope located on at least two subunits. More specifically, dot-blot analysis against various Aβ(1-42) and Aβ(1-40) standard preparations showed significant differences in recognition of Aβ(1-42) globulomer versus non-globulomer Aβ forms (standard Aβ(1-40)/(1-42) monomer preparation, aggregated Aβ(1-42) for specific 8F5 and 8C5 but not for the isoform non-specific antibodies 6G1 and 6E10. The globulomer specificity of 8F5 and 8C5 but not of 6G1 and 6E10, was confirmed by quantifying Aβ(1-42) globulomer, Aβ(1-42) monomer, Aß(1-40) monomer and soluble amyloid precursor protein alpha binding in sandwich ELISAs. Further, since these antibodies access the globulomer after native but not after SDS Western blotting, it is likely that each antibody recognizes a structural non-linear epitope in between subunits in the region of amino acids 20 to 30 of Aβ(1-42). Such specificity for globulomers is important because specifically targeting the globulomer form of Aβ with a globulomer preferential antibody such as, for example, 8F5 or 8C5 will: 1) avoid targeting insoluble amyloid deposits,

binding to which may account for inflammatory side effects observed during immunizations with insoluble Aβ; 2) spare Aβ monomer and APP that are reported to have precognitive physiological functions (Plan et al., J. of Neuroscience 23:5531-5535 (2003); and 3) increase the bioavailability of the antibody, as it would not be shaded or inaccessible through extensive binding to insoluble deposits.

The subject invention also includes isolated nucleotide sequences (or fragments thereof) encoding the variable light and heavy chains of monoclonal antibody 8F5 and 8CD as well as those nucleotide sequences (or fragments thereof) having sequences comprising, corresponding to, identical to, hybridizable to, or complementary to at least about 70% (e.g., 70% 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78% or 79%), preferably at least about 80% (e.g., 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88% or 89%), and more preferably at least about 90% (e.g, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99%) identity to these encoding nucleotide sequences. (All integers (and portions thereof) between and including 70% and 100% are considered to be within the scope of the present invention with respect to percent identity.) Such sequences may be derived from any source (e.g., either isolated from a natural source, produced via a semi-synthetic route, or synthesized *de novo*). In particular, such sequences may be isolated or derived from sources other than described in the examples (e.g., bacteria, fungus, algae, mouse or human).

In addition to the nucleotide sequences described above, the present invention also includes amino acid sequences of the variable light and heavy chains of monoclonal antibody 8F5 and monoclonal antibody 8C5 (or fragments of these amino acid sequences). Further, the present invention also includes amino acid sequences (or fragments thereof) comprising, corresponding to, identical to, or complementary to at least

about 70%, preferably at least about 80%, and more preferably at least about 90% identity to the amino acid sequences of the proteins of the present invention. (Again, all integers (and portions thereof) between and including 70% and 100% (as recited in connection with the nucleotide sequence identities noted above) are also considered to be within the scope of the present invention with respect to percent identity.)

For purposes of the present invention, a "fragment" of a nucleotide sequence is defined as a contiguous sequence of approximately at least 6, preferably at least about 8, more preferably at least about 10 nucleotides, and even more preferably at least about 15 nucleotides corresponding to a region of the specified nucleotide sequence.

The term "identity" refers to the relatedness of two sequences on a nucleotide-by-nucleotide basis over a particular comparison window or segment. Thus, identity is defined as the degree of sameness, correspondence or equivalence between the same strands (either sense or antisense) of two DNA segments (or two amino acid sequences). "Percentage of sequence identity" is calculated by comparing two optimally aligned sequences over a particular region, determining the number of positions at which the identical base or amino acid occurs in both sequences in order to yield the number of matched positions, dividing the number of such positions by the total number of positions in the segment being compared and multiplying the result by 100. Optimal alignment of sequences may be conducted by the algorithm of Smith & Waterman, Appl. Math. 2:482 (1981), by the algorithm of Needleman & Wunsch, J. Mol. Biol. 48:443 (1970), by the method of Pearson & Lipman, Proc. Natl. Acad. Sci. (USA) 85:2444 (1988) and by computer programs which implement the relevant algorithms (e.g., Clustal Macaw Pileup (http://cmgm.stanford.edu/biochem218/11Multiple.pdf; Higgins

et al., CABIOS. 5L151-153 (1989)), FASTDB (Intelligenetics), BLAST (National Center for Biomedical Information; Altschul et al., Nucleic Acids Research 25:3389-3402 (1997)), PILEUP (Genetics Computer Group, Madison, WI) or GAP, BESTFIT, FASTA and TFASTA (Wisconsin Genetics Software Package Release 7.0, Genetics Computer Group, Madison, WI). (See U.S. Patent No. 5,912,120.)

For purposes of the present invention, "complementarity" is defined as the degree of relatedness between two DNA segments. It is determined by measuring the ability of the sense strand of one DNA segment to hybridize with the anti-sense strand of the other DNA segment, under appropriate conditions, to form a double helix. A "complement" is defined as a sequence which pairs to a given sequence based upon the canonic base-pairing rules. For example, a sequence A-G-T in one nucleotide strand is "complementary" to T-C-A in the other strand.

In the double helix, adenine appears in one strand, thymine appears in the other strand. Similarly, wherever guanine is found in one strand, cytosine is found in the other. The greater the relatedness between the nucleotide sequences of two DNA segments, the greater the ability to form hybrid duplexes between the strands of the two DNA segments.

"Similarity" between two amino acid sequences is defined as the presence of a series of identical as well as conserved amino acid residues in both sequences. The higher the degree of similarity between two amino acid sequences, the higher the correspondence, sameness or equivalence of the two sequences. ("Identity between two amino acid sequences is defined as the presence of a series of exactly alike or invariant amino acid residues in both sequences.) The definitions of "complementarity", "identity" and "similarity" are well known to those of ordinary skill in the art.

"Encoded by" refers to a nucleic acid sequence which codes for a polypeptide sequence, wherein the polypeptide sequence or a portion thereof contains an amino acid sequence of at least 3 amino acids, more preferably at least 8 amino acids, and even more preferably at least 15 amino acids from a polypeptide encoded by the nucleic acid sequence.

Additionally, a nucleic acid molecule is "hybridizable" to another nucleic acid molecule when a single-stranded form of the nucleic acid molecule can anneal to the other nucleic acid molecule under the appropriate conditions of temperature and ionic strength (see Sambrook et al., "Molecular Cloning: A Laboratory Manual, Second Edition (1989), Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York)). The conditions of temperature and ionic strength determine the "stringency" of the hybridization.

The term "hybridization" as used herein is generally used to mean hybridization of nucleic acids at appropriate conditions of stringency as would be readily evident to those skilled in the art depending upon the nature of the probe sequence and target sequences. Conditions of hybridization and washing are well known in the art, and the adjustment of conditions depending upon the desired stringency by varying incubation time, temperature and/or ionic strength of the solution are readily accomplished. See, for example, Sambrook, J. et al., Molecular Cloning: A Laboratory Manual, 2nd edition, Cold spring harbor Press, Cold Spring harbor, N.Y., 1989, as noted above and incorporated herein by reference. (See also Short Protocols in Molecular Biology, ed. Ausubel et al. and Tijssen, Techniques in Biochemistry and Molecular Biology-Hybridization with Nucleic Acid Probes, "Overview of principles of hybridization and the strategy of nucleic acid assays" (1993), both incorporated herein by reference.) Specifically, the choice of conditions is

dictated by the length of the sequences being hybridized, in particular, the length of the probe sequence, the relative G-C content of the nucleic acids and the amount of mismatches to be permitted. Low stringency conditions are preferred when partial hybridization between strands that have lesser degrees of complementarity is desired. When perfect or near perfect complementarity is desired, high stringency conditions are preferred. For typical high stringency conditions, the hybridization solution contains 6 X S.S.C., 0.01 M EDTA, 1x Denhardt's solution and 0.5% SDS. Hybridization is carried out at about 68 degrees Celsius for about 3 to 4 hours for fragments of cloned DNA and for about 12 to about 16 hours for total eukaryotic DNA. For moderate stringencies, one may utilize filter pre-hybridizing and hybridizing with a solution of 3 X sodium chloride, sodium citrate (SSC), 50% formamide (0.1 M of this buffer at pH 7.5) and 5 X Denhardt's solution. One may then pre-hybridize at 37 degrees Celsius for 4 hours, followed by hybridization at 37 degrees Celsius with an amount of labeled probe equal to 3,000,000 cpm total for 16 hours, followed by a wash in 2 X SSC and 0.1% SDS solution, a wash of 4 times for 1 minute each at room temperature and 4 times at 60 degrees Celsius for 30 minutes each. Subsequent to drying, one exposes to film. For lower stringencies, the temperature of hybridization is reduced to about 12 degrees Celsius below the melting temperature (T_m) of the duplex. The T_m is known to be a function of the G-C content and duplex length as well as the ionic strength of the solution.

"Hybridization" requires that two nucleic acids contain complementary sequences. However, depending on the stringency of the hybridization, mismatches between bases may occur. As noted above, the appropriate stringency for hybridizing nucleic acids depends on the length of the nucleic acids and the degree of complementation. Such variables are well known

in the art. More specifically, the greater the degree of similarity or homology between two nucleotide sequences, the greater the value of Tm for hybrids of nucleic acids having those sequences. For hybrids of greater than 100 nucleotides in length, equations for calculating Tm have been derived (see Sambrook et al., *supra*). For hybridization with shorter nucleic acids, the position of mismatches becomes more important, and the length of the oligonucleotide determines its specificity (see Sambrook et al., *supra*).

As used herein, an "isolated nucleic acid fragment or sequence" is a polymer of RNA or DNA that is single- or double-stranded, optionally containing synthetic, non-natural or altered nucleotide bases. An isolated nucleic acid fragment in the form of a polymer of DNA may be comprised of one or more segments of cDNA, genomic DNA or synthetic DNA. (A "fragment" of a specified polynucleotide refers to a polynucleotide sequence which comprises a contiguous sequence of approximately at least about 6 nucleotides, preferably at least about 8 nucleotides, more preferably at least about 10 nucleotides, and even more preferably at least about 15 nucleotides, and most preferable at least about 25 nucleotides identical or complementary to a region of the specified nucleotide sequence.) Nucleotides (usually found in their 5'-monophosphate form) are referred to by their single letter designation as follows: "A" for adenylate or deoxyadenylate (for RNA or DNA, respectively), "C" for cytidylate or deoxycytidylate, "G" for guanylate or deoxyguanylate, "U" for uridylate, "T" for deoxythymidylate, "R" for purines (A or G), "Y" for pyrimidines (C or T), "K" for G or T, "H" for A or C or T, "I" for inosine, and "N" for any nucleotide.

The terms "fragment or subfragment that is functionally equivalent" and "functionally equivalent fragment or subfragment" are used interchangeably herein. These terms

refer to a portion or subsequence of an isolated nucleic acid fragment in which the ability to alter gene expression or produce a certain phenotype is retained whether or not the fragment or subfragment encodes an active enzyme. For example, the fragment or subfragment can be used in the design of chimeric constructs to produce the desired phenotype in a transformed plant. Chimeric constructs can be designed for use in co-suppression or antisense by linking a nucleic acid fragment or subfragment thereof, whether or not it encodes an active enzyme, in the appropriate orientation relative to a plant promoter sequence.

The terms "homology", "homologous", "substantially similar" and "corresponding substantially" are used interchangeably herein. They refer to nucleic acid fragments wherein changes in one or more nucleotide bases does not affect the ability of the nucleic acid fragment to mediate gene expression or produce a certain phenotype. These terms also refer to modifications of the nucleic acid fragments of the instant invention such as deletion or insertion of one or more nucleotides that do not substantially alter the functional properties of the resulting nucleic acid fragment relative to the initial, unmodified fragment. It is therefore understood, as those skilled in the art will appreciate, that the invention encompasses more than the specific exemplary sequences.

"Gene" refers to a nucleic acid fragment that expresses a specific protein, including regulatory sequences preceding (5' non-coding sequences) and following (3' non-coding sequences) the coding sequence.

"Native gene" refers to a gene as found in nature with its own regulatory sequences. In contrast, "chimeric construct" refers to a combination of nucleic acid fragments that are not normally found together in nature. Accordingly, a chimeric

construct may comprise regulatory sequences and coding sequences that are derived from different sources, or regulatory sequences and coding sequences derived from the same source, but arranged in a manner different than that normally found in nature. (The term "isolated" means that the sequence is removed from its natural environment.)

A "foreign" gene refers to a gene not normally found in the host organism, but that is introduced into the host organism by gene transfer. Foreign genes can comprise native genes inserted into a non-native organism, or chimeric constructs. A "transgene" is a gene that has been introduced into the genome by a transformation procedure.

"Coding sequence" refers to a DNA sequence that codes for a specific amino acid sequence. "Regulatory sequences" refer to nucleotide sequences located upstream (5' non-coding sequences), within, or downstream (3' non-coding sequences) of a coding sequence, and which influence the transcription, RNA processing or stability, or translation of the associated coding sequence. Regulatory sequences may include, but are not limited to, promoters, translation leader sequences, introns, and polyadenylation recognition sequences.

"Promoter" or "regulatory gene sequence" refers to a DNA sequence capable of controlling the expression of a coding sequence or functional RNA. The sequence consists of proximal and more distal upstream elements, the latter elements often referred to as enhancers. Accordingly, an "enhancer" is a DNA sequence which can stimulate promoter or regulatory gene sequence activity and may be an innate element of the promoter or a heterologous element inserted to enhance the level or tissue-specificity of a promoter. Promoter sequences can also be located within the transcribed portions of genes, and/or downstream of the transcribed sequences. Promoters may be derived in their entirety from a native gene, or be composed

of different elements derived from different promoters found in nature, or even comprise synthetic DNA segments. It is understood by those skilled in the art that different promoters may direct the expression of a gene in different tissues or cell types, or at different stages of development, or in response to different environmental conditions. Promoters which cause a gene to be expressed in most host cell types at most times are commonly referred to as "constitutive promoters". New promoters of various types useful in plant cells are constantly being discovered; numerous examples may be found in the compilation by Okamuro and Goldberg, Biochemistry of Plants 15:1-82 (1989). It is further recognized that since in most cases the exact boundaries of regulatory sequences have not been completely defined, DNA fragments of some variation may have identical promoter activity.

An "intron" is an intervening sequence in a gene that does not encode a portion of the protein sequence. Thus, such sequences are transcribed into RNA but are then excised and are not translated. The term is also used for the excised RNA sequences. An "exon" is a portion of the gene sequence that is transcribed and is found in the mature messenger RNA derived from the gene, but is not necessarily a part of the sequence that encodes the final gene product.

The "translation leader sequence" refers to a DNA sequence located between the promoter sequence of a gene and the coding sequence. The translation leader sequence is present in the fully processed mRNA upstream of the translation start sequence. The translation leader sequence may affect processing of the primary transcript to mRNA, mRNA stability or translation efficiency. Examples of translation leader sequences have been described (Turner, R. and Foster, G. D. (1995) *Molecular Biotechnology* 3:225).

The "3' non-coding sequences" refer to DNA sequences located downstream of a coding sequence and include polyadenylation recognition sequences and other sequences encoding regulatory signals capable of affecting mRNA processing or gene expression. The polyadenylation signal is usually characterized by affecting the addition of polyadenylic acid tracts to the 3' end of the mRNA precursor. The use of different 3' non-coding sequences is exemplified by Ingelbrecht et al., Plant Cell 1:671-680 (1989).

"RNA transcript" refers to the product resulting from RNA polymerase-catalyzed transcription of a DNA sequence. When the RNA transcript is a perfect complementary copy of the DNA sequence, it is referred to as the primary transcript or it may be a RNA sequence derived from post-transcriptional processing of the primary transcript and is referred to as the mature RNA. "Messenger RNA (mRNA)" refers to the RNA that is without introns and that can be translated into protein by the cell. "cDNA" refers to a DNA that is complementary to and synthesized from a mRNA template using the enzyme reverse transcriptase. The cDNA can be single-stranded or converted into the double-stranded form using the Klenow fragment of DNA polymerase I. "Sense" RNA refers to RNA transcript that includes the mRNA and can be translated into protein within a cell or *in vitro*. "Antisense RNA" refers to an RNA transcript that is complementary to all or part of a target primary transcript or mRNA and that blocks the expression of a target gene (U.S. Patent No. 5,107,065). The complementarity of an antisense RNA may be with any part of the specific gene transcript, i.e., at the 5' non-coding sequence, 3' non-coding sequence, introns, or the coding sequence. "Functional RNA" refers to antisense RNA, ribozyme RNA, or other RNA that may not be translated but yet has an effect on cellular processes. The terms "complement" and "reverse complement" are used

interchangeably herein with respect to mRNA transcripts, and are meant to define the antisense RNA of the message.

The term "endogenous RNA" refers to any RNA which is encoded by any nucleic acid sequence present in the genome of the host prior to transformation with the recombinant construct of the present invention, whether naturally-occurring or non-naturally occurring, i.e., introduced by recombinant means, mutagenesis, etc.

The term "non-naturally occurring" means artificial, not consistent with what is normally found in nature.

The term "operably linked" refers to the association of nucleic acid sequences on a single nucleic acid fragment so that the function of one is regulated by the other. For example, a promoter is operably linked with a coding sequence when it is capable of regulating the expression of that coding sequence (i.e., that the coding sequence is under the transcriptional control of the promoter). Coding sequences can be operably linked to regulatory sequences in a sense or antisense orientation. In another example, the complementary RNA regions of the invention can be operably linked, either directly or indirectly, 5' to the target mRNA, or 3' to the target mRNA, or within the target mRNA, or a first complementary region is 5' and its complement is 3' to the target mRNA.

The term "expression", as used herein, refers to the production of a functional end-product. Expression of a gene involves transcription of the gene and translation of the mRNA into a precursor or mature protein. "Antisense inhibition" refers to the production of antisense RNA transcripts capable of suppressing the expression of the target protein. "Co-suppression" refers to the production of sense RNA transcripts capable of suppressing the expression of identical

or substantially similar foreign or endogenous genes (U.S. Patent No. 5,231,020).

"Mature" protein refers to a post-translationally processed polypeptide; i.e., one from which any pre- or pro-peptides present in the primary translation product have been removed. "Precursor" protein refers to the primary product of translation of mRNA; i.e., with pre- and pro-peptides still present. Pre- and pro-peptides may be but are not limited to intracellular localization signals.

"Stable transformation" refers to the transfer of a nucleic acid fragment into a genome of a host organism, resulting in genetically stable inheritance. In contrast, "transient transformation" refers to the transfer of a nucleic acid fragment into the nucleus, or DNA-containing organelle, of a host organism resulting in gene expression without integration or stable inheritance. Host organisms containing the transformed nucleic acid fragments are referred to as "transgenic" organisms. The term "transformation" as used herein refers to both stable transformation and transient transformation.

Standard recombinant DNA and molecular cloning techniques used herein are well known in the art and are described more fully in Sambrook, J., Fritsch, E.F. and Maniatis, T., Molecular Cloning: A Laboratory Manual; Cold Spring Harbor Laboratory Press: Cold Spring Harbor, 1989 (hereinafter "Sambrook").

The term "recombinant" refers to an artificial combination of two otherwise separated segments of sequence, e.g., by chemical synthesis or by the manipulation of isolated segments of nucleic acids by genetic engineering techniques.

"PCR" or "Polymerase Chain Reaction" is a technique for the synthesis of large quantities of specific DNA segments, consists of a series of repetitive cycles (Perkin Elmer Cetus

Instruments, Norwalk, CT). Typically, the double stranded DNA is heat denatured, the two primers complementary to the 3' boundaries of the target segment are annealed at low temperature and then extended at an intermediate temperature. One set of these three consecutive steps is referred to as a cycle.

Polymerase chain reaction ("PCR") is a powerful technique used to amplify DNA millions of fold, by repeated replication of a template, in a short period of time. (Mullis et al., Cold Spring Harbor Symp. Quant. Biol. 51:263-273 (1986); Erlich et al., European Patent Application No. 50,424; European Patent Application No. 84,796; European Patent Application No. 258,017; European Patent Application No. 237,362; Mullis, European Patent Application No. 201,184; Mullis et al., U.S. Patent No. 4,683,202; Erlich, U.S. Patent No. 4,582,788; and Saiki et al., U.S. Patent No. 4,683,194). The process utilizes sets of specific in vitro synthesized oligonucleotides to prime DNA synthesis. The design of the primers is dependent upon the sequences of DNA that are to be analyzed. The technique is carried out through many cycles (usually 20-50) of melting the template at high temperature, allowing the primers to anneal to complementary sequences within the template and then replicating the template with DNA polymerase.

The products of PCR reactions are analyzed by separation in agarose gels followed by ethidium bromide staining and visualization with UV transillumination. Alternatively, radioactive dNTPs can be added to the PCR in order to incorporate label into the products. In this case the products of PCR are visualized by exposure of the gel to x-ray film. The added advantage of radiolabeling PCR products is that the levels of individual amplification products can be quantitated.

The terms "recombinant construct", "expression construct" and "recombinant expression construct" are used interchangeably herein. These terms refer to a functional unit of genetic material that can be inserted into the genome of a cell using standard methodology well known to one skilled in the art. Such construct may be itself or may be used in conjunction with a vector. If a vector is used then the choice of vector is dependent upon the method that will be used to transform host plants as is well known to those skilled in the art. For example, a plasmid can be used. The skilled artisan is well aware of the genetic elements that must be present on the vector in order to successfully transform, select and propagate host cells comprising any of the isolated nucleic acid fragments of the invention. The skilled artisan will also recognize that different independent transformation events will result in different levels and patterns of expression (Jones et al., (1985) EMBO J. 4:2411-2418; De Almeida et al., (1989) Mol. Gen. Genetics *218*:78-86), and thus that multiple events must be screened in order to obtain lines displaying the desired expression level and pattern. Such screening may be accomplished by Southern analysis of DNA, Northern analysis of mRNA expression, Western analysis of protein expression, or phenotypic analysis.

A "monoclonal antibody" as used herein is intended to refer to one of a preparation of antibody molecules containing antibodies which share a common heavy chain and common light chain amino acid sequence, in contrast with an antibody from a "polyclonal" antibody preparation which contains a mixture of different antibodies. Monoclonal antibodies can be generated by several novel technologies like phage, bacteria, yeast or ribosomal display, as well as classical methods exemplified by hybridoma-derived antibodies (*e.g.*, an antibody secreted by a hybridoma prepared by hybridoma technology, such as the

standard Kohler and Milstein hybridoma methodology ((1975) Nature 256:495-497). Thus, a non-hybridoma-derived agonistic antibody of the invention is still referred to as a monoclonal antibody although it may have been derived by non-classical methodologies.

An "isolated antibody", as used herein, is intended to refer to an antibody that is substantially free of other antibodies having different antigenic specificities (e.*g*., an isolated antibody that specifically binds to a globulomer is substantially free of antibodies that specifically bind antigens other than a globulomer). An isolated antibody that specifically binds a globulomer may, however, have cross-reactivity to other antigens. Moreover, an isolated antibody may be substantially free of other cellular material and/or chemicals.

The term "antigen-binding portion" of an antibody (or simply "antibody portion"), as used herein, refers to one or more fragments of an antibody that retain the ability to specifically bind to an antigen. It has been shown that the antigen-binding function of an antibody can be performed by fragments of a full-length antibody. Such antibody embodiments may also be bispecific, dual specific, or multi-specific formats; specifically binding to two or more different antigens. Examples of binding fragments encompassed within the term "antigen-binding portion" of an antibody include (i) a Fab fragment, a monovalent fragment consisting of the VL, VH, CL and CH1 domains; (ii) a $F(ab')_2$ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) a Fd fragment consisting of the VH and CH1 domains; (iv) a Fv fragment consisting of the VL and VH domains of a single arm of an antibody, (v) a dAb fragment (Ward *et al.*, (1989) *Nature*

341:544-546), which comprises a single variable domain; and (vi) an isolated complementarity determining region (CDR). Furthermore, although the two domains of the Fv fragment, VL and VH, are coded for by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the VL and VH regions pair to form monovalent molecules (known as single chain Fv (scFv); see *e.g.*, Bird *et al.* (1988) *Science* 242:423-426; and Huston *et al.* (1988) *Proc. Natl. Acad. Sci. USA* 85:5879-5883). Such single chain antibodies are also intended to be encompassed within the term "antigen-binding portion" of an antibody. Other forms of single chain antibodies, such as diabodies are also encompassed. Diabodies are bivalent, bispecific antibodies in which VH and VL domains are expressed on a single polypeptide chain, but using a linker that is too short to allow for pairing between the two domains on the same chain, thereby forcing the domains to pair with complementary domains of another chain and creating two antigen binding sites (see *e.g.*, Holliger, P., *et al.* (1993) *Proc. Natl. Acad. Sci. USA* 90:6444-6448; Poljak, R.J., *et al.* (1994) *Structure* 2:1121-1123). Such antibody binding portions are known in the art (Kontermann and Dubel eds., Antibody Engineering (2001) Springer-Verlag. New York. 790 pp. (ISBN 3-540-41354-5).

Still further, an antibody or antigen-binding portion thereof may be part of a larger immunoadhesion molecules, formed by covalent or noncovalent association of the antibody or antibody portion with one or more other proteins or peptides. Examples of such immunoadhesion molecules include use of the streptavidin core region to make a tetrameric scFv molecule (Kipriyanov, S.M., *et al.* (1995) *Human Antibodies and Hybridomas* 6:93-101) and use of a cysteine residue, a marker peptide and a C-terminal polyhistidine tag to make bivalent and biotinylated scFv molecules (Kipriyanov, S.M., *et al.*

(1994) *Mol. Immunol.* 31:1047-1058). Antibody portions, such as Fab and $F(ab')_2$ fragments, can be prepared from whole antibodies using conventional techniques, such as papain or pepsin digestion, respectively, of whole antibodies. Moreover, antibodies, antibody portions and immunoadhesion molecules can be obtained using standard recombinant DNA techniques, as described herein.

The term "recombinant human antibody", as used herein, is intended to include all human antibodies that are prepared, expressed, created or isolated by recombinant means, such as antibodies expressed using a recombinant expression vector transfected into a host cell, antibodies isolated from a recombinant, combinatorial human antibody library (Hoogenboom H.R., (1997) *TIB Tech.* 15:62-70; Azzazy H., and Highsmith W.E., (2002) *Clin. Biochem.* 35:425-445; Gavilondo J.V., and Larrick J.W. (2002) *BioTechniques* 29:128-145; Hoogenboom H., and Chames P. (2000) *Immunology Today* 21:371-378), antibodies isolated from an animal (e.g., a mouse) that is transgenic for human immunoglobulin genes (see e.g., Taylor, L. D., et al. (1992) Nucl. Acids Res. 20:6287-6295; Kellermann S-A., and Green L.L. (2002) *Current Opinion in Biotechnology* 13:593-597; Little M. et al (2000) *Immunology Today* 21:364-370) or antibodies prepared, expressed, created or isolated by any other means that involves splicing of human immunoglobulin gene sequences to other DNA sequences. Such recombinant human antibodies have variable and constant regions derived from human germline immunoglobulin sequences. In certain embodiments, however, such recombinant human antibodies are subjected to in vitro mutagenesis (or, when an animal transgenic for human Ig sequences is used, in vivo somatic mutagenesis) and thus the amino acid sequences of the VH and VL regions of the recombinant antibodies are sequences that,

while derived from and related to human germline VH and VL sequences, may not naturally exist within the human antibody germline repertoire in vivo. (See also Kabat et al. Sequences of Proteins of Immunological Interest, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242, 1991). The human antibodies of the present invention, however, may include amino acid residues not encoded by human germline immunoglobulin sequences (*e.g.*, mutations introduced by random or site-specific mutagenesis *in vitro* or by somatic mutation *in vivo*). (See also Harlow and Lane, Antibodies: A Laboratory Manual, New York: Cold Spring Harbor Press, 1990).

The term "chimeric antibody" refers to antibodies which comprise heavy and light chain variable region sequences from one species and constant region sequences from another species, such as antibodies having murine heavy and light chain variable regions linked to human constant regions.

The term "CDR-grafted antibody" refers to antibodies which comprise heavy and light chain variable region sequences from one species but in which the sequences of one or more of the CDR regions of V_H and/or VL are replaced with CDR sequences of another species, such as antibodies having murine heavy and light chain variable regions in which one or more of the murine CDRs (*e.g.*, CDR3) has been replaced with human CDR sequences.

Recombinant human antibodies of the present invention have variable regions, and may also include constant regions, derived from human germline immunoglobulin sequences. (See Kabat et al. (1991) *supra*.) In certain embodiments, however, such recombinant human antibodies are subjected to *in vitro* mutagenesis (or, when an animal transgenic for human Ig sequences is used, *in vivo* somatic mutagenesis), and thus the amino acid sequences of the VH and VL regions of the

recombinant antibodies are sequences that, while derived from and related to human germline VH and VL sequences, may not naturally exist within the human antibody germline repertoire *in vivo*. In certain embodiments, however, such recombinant antibodies are the result of selective mutagenesis or backmutation or both.

The term "backmutation" refers to a process in which some or all of the somatically mutated amino acids of a human antibody are replaced with the corresponding germline residues from a homologous germline antibody sequence. The heavy and light chain sequences of a human antibody of the invention are aligned separately with the germline sequences in the VBASE database to identify the sequences with the highest homology. VBASE is a comprehensive directory of all human germline variable region sequences compiled from published sequences, including current releases of GenBank and EMBL data libraries. The database has been developed at the MRC Centre for Protein Engineering (Cambridge, UK) as a depository of the sequenced human antibody genes (website: http://www.mrc-cpe.cam.ac.uk/vbase-intro.php?menu=901). Differences in the human antibody of the invention are returned to the germline sequence by mutating defined nucleotide positions encoding such different amino acids. The role of each amino acid thus identified as a candidate for backmutation should be investigated for a direct or indirect role in antigen binding, and any amino acid found after mutation to affect any desirable characteristic of the human antibody should not be included in the final human antibody. To minimize the number of amino acids subject to backmutation, those amino acid positions found to be different from the closest germline sequence, but identical to the corresponding amino acid in a second germline sequence, can remain, provided that the second germline sequence is identical and co-linear to the sequence

of the human antibody of the invention for at least 10, preferably 12, amino acids on both sides of the amino acid in question. Backmutation may occur at any stage of antibody optimization.

A "labeled binding protein" is a protein wherein an antibody or antibody portion of the invention is derivatized or linked to another functional molecule (e.g., another peptide or protein). For example, a labeled binding protein of the invention can be derived by functionally linking an antibody or antibody portion of the invention (by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other molecular entities, such as another antibody (e.g., a bispecific antibody or a diabody), a detectable agent, a cytotoxic agent, a pharmaceutical agent, and/or a protein or peptide that can mediate associate of the antibody or antibody portion with another molecule (such as a streptavidin core region or a polyhistidine tag).

For purposes of the present invention, a "glycosylated binding protein" comprises a protein wherein the antibody or antigen-binding portion thereof comprises one or more carbohydrate residues. Nascent *in vivo* protein production may undergo further processing, known as post-translational modification. In particular, sugar (glycosyl) residues may be added enzymatically, a process known as glycosylation. The resulting proteins bearing covalently linked oligosaccharide side chains are known as glycosylated proteins or glycoproteins. Antibodies are glycoproteins with one or more carbohydrate residues in the Fc domain, as well as the variable domain. Carbohydrate residues in the Fc domain have important effect on the effector function of the Fc domain, with minimal effect on antigen binding or half-life of the antibody (R. Jefferis, *Biotechnol. Prog.* 21 (2005), pp. 11-16). In contrast, glycosylation of the variable domain may

have an effect on the antigen binding activity of the antibody. Glycosylation in the variable domain may have a negative effect on antibody binding affinity, likely due to steric hindrance (Co, M.S., et al., Mol. Immunol. (1993) 30:1361- 1367), or result in increased affinity for the antigen (Wallick, S.C., et al., Exp. Med. (1988) 168:1099-1109; Wright, A., et al., EMBO J. (1991) 10:2717 2723). Further, glycosylation site mutants can be made in which the O- or N-linked glycosylation site of the binding protein has been mutated. One skilled in the art can generate such mutants using standard well-known technologies. Glycosylation site mutants that retain the biological activity but have increased or decreased binding activity are also contemplated.

Further, the glycosylation of the antibody or antigen-binding portion of the invention can modified. For example, an aglycoslated antibody can be made (i.e., the antibody lacks glycosylation). Glycosylation can be altered to, for example, increase the affinity of the antibody for antigen. Such carbohydrate modifications can be accomplished by, for example, altering one or more sites of glycosylation within the antibody sequence. For example, one or more amino acid substitutions can be made that result in elimination of one or more variable region glycosylation sites to thereby eliminate glycosylation at that site. Such a glycosylation may increase the affinity of the antibody for antigen. Such an approach is described in further detail in International Application Publication No. WO 03/016466A2, and U.S. Patent Nos. 5,714,350 and 6,350,861, each of which is incorporated herein by reference in its entirety.

Additionally or alternatively, a modified antibody can be made that has an altered type of glycosylation, such as a hypofucosylated antibody having reduced amounts of fucosyl residues or an antibody having increased bisecting GlcNAc

structures. Such altered glycosylation patterns have been demonstrated to increase the ADCC ability of antibodies. Such carbohydrate modifications can be accomplished by, for example, expressing the antibody in a host cell with altered glycosylation machinery. Cells with altered glycosylation machinery have been described in the art and can be used as host cells in which to express recombinant antibodies of the invention to thereby produce an antibody with altered glycosylation. (See, for example, Shields, R.L. et al. (2002) J. Biol. Chem. 277:26733-26740; Umana et al. (1999) Nat. Biotech. 17:176-1, as well as, European Patent No: EP 1,176,195; International Application Publication Number WO 03/035835 and WO 99/5434280, each of which is incorporated herein by reference in its entirety.)

Protein glycosylation depends on the amino acid sequence of the protein of interest, as well as the host cell in which the protein is expressed. Different organisms may produce different glycosylation enzymes (e.g., glycosyltransferases and glycosidases), and have different substrates (nucleotide sugars) available. Due to such factors, protein glycosylation pattern, and composition of glycosyl residues, may differ depending on the host system in which the particular protein is expressed. Glycosyl residues useful in the invention may include, but are not limited to, glucose, galactose, mannose, fucose, n-acetylglucosamine and sialic acid. Preferably the glycosylated binding protein comprises glycosyl residues such that the glycosylation pattern is human.

It is known to those skilled in the art that differing protein glycosylation may result in differing protein characteristics. For instance, the efficacy of a therapeutic protein produced in a microorganism host, such as yeast, and glycosylated utilizing the yeast endogenous pathway may be reduced compared to that of the same protein expressed in a

mammalian cell, such as a CHO cell line. Such glycoproteins may also be immunogenic in humans and show reduced half-life *in vivo* after administration. Specific receptors in humans and other animals may recognize specific glycosyl residues and promote the rapid clearance of the protein from the bloodstream. Other adverse effects may include changes in protein folding, solubility, susceptibility to proteases, trafficking, transport, compartmentalization, secretion, recognition by other proteins or factors, antigenicity, or allergenicity. Accordingly, a practitioner may prefer a therapeutic protein with a specific composition and pattern of glycosylation, for example glycosylation composition and pattern identical, or at least similar, to that produced in human cells or in the species-specific cells of the intended subject animal.

Expressing glycosylated proteins different from that of a host cell may be achieved by genetically modifying the host cell to express heterologous glycosylation enzymes. Using techniques known in the art a practitioner may generate antibodies or antigen-binding portions thereof exhibiting human protein glycosylation. For example, yeast strains have been genetically modified to express non-naturally occurring glycosylation enzymes such that glycosylated proteins (glycoproteins) produced in these yeast strains exhibit protein glycosylation identical to that of animal cells, especially human cells (U.S Patent Application Publication Nos. 20040018590 and 20020137134 and International Application Publication No. WO 05/100584 A2).

Further, it will be appreciated by one skilled in the art that a protein of interest may be expressed using a library of host cells genetically engineered to express various glycosylation enzymes, such that member host cells of the library produce the protein of interest with variant

glycosylation patterns. A practitioner may then select and isolate the protein of interest with particular novel glycosylation patterns. Preferably, the protein having a particularly selected novel glycosylation pattern exhibits improved or altered biological properties.

The invention also provides a method for making the monoclonal antibodies of the invention from non-human, non-mouse animals by immunizing non-human transgenic animals that comprise human immunoglobulin loci. One may produce such animals using methods known in the art. In a preferred embodiment, the non-human animals may be rats, sheep, pigs, goats, cattle or horses. Antibody-producing immortalized hybridomas may be prepared from the immunized animal. After immunization, the animal is sacrificed and the splenic B cells are fused to immortalized myeloma cells as is well known in the art. See, e.g., Harlow and Lane, *supra*. In a preferred embodiment, the myeloma cells do not secrete immunoglobulin polypeptides (a non-secretory cell line). After fusion and antibiotic selection, the hybridomas are screened using an antigen (for example, a globulomer) or a portion thereof, or a cell expressing the antigen of interest. In a preferred embodiment, the initial screening is performed using an enzyme-linked immunoassay (ELISA) or a radioimmunoassay (RIA), preferably an ELISA. An example of ELISA screening is provided in International Application Publication No. WO 00/37504, herein incorporated by reference.

The antibody-producing hybridomas are selected, cloned and further screened for desirable characteristics, including robust hybridoma growth, high antibody production and desirable antibody characteristics, as discussed further below. Hybridomas may be cultured and expanded *in vivo* in syngeneic animals, in animals that lack an immune system, e.g., nude mice, or in cell culture *in vitro*. Methods of

selecting, cloning and expanding hybridomas are well known to those of ordinary skill in the art. Preferably, the immunized animal is a non-human animal that expresses human immunoglobulin genes and the splenic B cells are fused to a myeloma derived from the same species as the non-human animal.

In one aspect, the invention provides hybridomas that produce monoclonal antibodies to be used in the treatment, diagnosis and prevention of Alzheimer's Disease. In a preferred embodiment, the hybridomas are mouse hybridomas. In another preferred embodiment, the hybridomas are produced in a non-human, non-mouse species such as rats, sheep, pigs, goats, cattle or horses. In another embodiment, the hybridomas are human hybridomas, in which a human non-secretory myeloma is fused with a human cell expressing an antibody against a globulomer.

Recombinant antibodies may be generated from single, isolated lymphocytes using a procedure referred to in the art as the selected lymphocyte antibody method (SLAM), as described in U.S. Patent No. 5,627,052, International Application Publication No. WO 92/02551 and Babcock, J.S. *et al.* (1996) *Proc. Natl. Acad. Sci. USA* 93:7843-7848. In this method, single cells secreting antibodies of interest (*e.g.*, lymphocytes derived from the immunized animal) are screened using an antigen-specific hemolytic plaque assay, wherein the antigen (e.g., globulomer), or a fragment thereof, is coupled to sheep red blood cells using a linker, such as biotin, and used to identify single cells that secrete antibodies with specificity for the antigen. Following identification of antibody-secreting cells of interest, heavy- and light-chain variable region cDNAs are rescued from the cells by reverse transcriptase-PCR and these variable regions can then be expressed, in the context of appropriate immunoglobulin constant regions (*e.g.*, human constant regions), in mammalian

host cells, such as COS or CHO cells. The host cells transfected with the amplified immunoglobulin sequences, derived from *in vivo* selected lymphocytes, can then undergo further analysis and selection *in vitro*, for example by panning the transfected cells to isolate cells expressing antibodies to IL-18. The amplified immunoglobulin sequences further can be manipulated *in vitro*, such as by *in vitro* affinity maturation methods such as those described in International Application Publication No. WO 97/29131 and International Application Publication No. WO 00/56772.

The term "chimeric antibody" refers to antibodies which comprise heavy and light chain variable region sequences from one species and constant region sequences from another species, such as antibodies having murine heavy and light chain variable regions linked to human constant regions.

The term "CDR-grafted antibody" refers to antibodies which comprise heavy and light chain variable region sequences from one species but in which the sequences of one or more of the CDR regions of VH and/or VL are replaced with CDR sequences of another species, such as antibodies having murine heavy and light chain variable regions in which one or more of the murine CDRs (*e.g.*, CDR3) has been replaced with human CDR sequences.

The term "humanized antibody" refers to antibodies which comprise heavy and light chain variable region sequences from a nonhuman species (*e.g.*, a mouse) but in which at least a portion of the VH and/or VL sequence has been altered to be more "human-like", *i.e.*, more similar to human germline variable sequences. One type of humanized antibody is a CDR-grafted antibody in which human CDR sequences are introduced into nonhuman VH and VL sequences to replace the corresponding nonhuman CDR sequences. In particular, the term "humanized antibody" is an antibody or a variant, derivative, analog or

fragment thereof which immunospecifically binds to an antigen of interest and which comprises a framework (FR) region having substantially the amino acid sequence of a human antibody and a complementary determining region (CDR) having substantially the amino acid sequence of a non-human antibody. As used herein, the term "substantially" in the context of a CDR refers to a CDR having an amino acid sequence at least 80%, preferably at least 85%, at least 90%, at least 95%, at least 98% or at least 99% identical to the amino acid sequence of a non-human antibody CDR. A humanized antibody comprises substantially all of at least one, and typically two, variable domains (Fab, Fab', F(ab') 2, FabC, Fv) in which all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin (i.e., donor antibody) and all or substantially all of the framework regions are those of a human immunoglobulin consensus sequence. Preferably, a humanized antibody also comprises at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. In some embodiments, a humanized antibody contains both the light chain as well as at least the variable domain of a heavy chain. The antibody also may include the CH1, hinge, CH2, CH3, and CH4 regions of the heavy chain. In some embodiments, a humanized antibody only contains a humanized light chain. In other embodiments, a humanized antibody only contains a humanized heavy chain. In specific embodiments, a humanized antibody only contains a humanized variable domain of a light chain and/or humanized heavy chain.

The humanized antibody can be selected from any class of immunoglobulins, including IgM, IgG, IgD, IgA and IgE, and any isotype, including without limitation IgG 1, IgG2, IgG3 and IgG4. The humanized antibody may comprise sequences from more than one class or isotype, and particular constant domains may

be selected to optimize desired effector functions using techniques well-known in the art.

The framework and CDR regions of a humanized antibody need not correspond precisely to the parental sequences, e.g., the donor antibody CDR or the consensus framework may be mutagenized by substitution, insertion and/or deletion of at least one amino acid residue so that the CDR or framework residue at that site does not correspond to either the donor antibody or the consensus framework. In a preferred embodiment, such mutations, however, will not be extensive. Usually, at least 80%, preferably at least 85%, more preferably at least 90%, and most preferably at least 95% of the humanized antibody residues will correspond to those of the parental FR and CDR sequences. As used herein, the term "consensus framework" refers to the framework region in the consensus immunoglobulin sequence. Further, as used herein, the term "consensus immunoglobulin sequence" refers to the sequence formed from the most frequently occurring amino acids (or nucleotides) in a family of related immunoglobulin sequences (see e.g., Winnaker, From Genes to Clones (Verlagsgesellschaft, Weinheim, Germany 1987). In a family of immunoglobulins, each position in the consensus sequence is occupied by the amino acid occurring most frequently at that position in the family. If two amino acids occur equally frequently, either can be included in the consensus sequence.

The term "activity" includes activities such as the binding specificity/affinity of an antibody for an antigen.

The term "epitope" includes any polypeptide determinant capable of specific binding to an immunoglobulin or T-cell receptor. In certain embodiments, epitope determinants include chemically active surface groupings of molecules such as amino acids, sugar side chains, phosphoryl, or sulfonyl, and, in certain embodiments, may have specific three dimensional

structural characteristics, and/or specific charge characteristics. An epitope is a region of an antigen that is bound by an antibody. In certain embodiments, an antibody is said to specifically bind an antigen when it preferentially recognizes its target antigen in a complex mixture of proteins and/or macromolecules.

The term "surface plasmon resonance", as used herein, refers to an optical phenomenon that allows for the analysis of real-time biospecific interactions by detection of alterations in protein concentrations within a biosensor matrix, for example using the BIAcore system (Pharmacia Biosensor AB, Uppsala, Sweden and Piscataway, NJ). For further descriptions, see Jönsson, U., *et al.* (1993) *Ann. Biol. Clin.* 51:19-26; Jönsson, U., *et al.* (1991) *Biotechniques* 11:620-627; Johnsson, B., *et al.* (1995) *J. Mol. Recognit.* 8:125-131; and Johnnson, B., *et al.* (1991) *Anal. Biochem.* 198:268-277.

The term "K_{on}", as used herein, is intended to refer to the "on rate" constant for association of an antibody to the antigen to form the antibody/antigen complex as is known in the art.

The term "K_{off}", as used herein, is intended to refer to the "off rate" constant for dissociation of an antibody from the antibody/antigen complex as is known in the art.

The term "K_d", as used herein, is intended to refer to the "dissociation constant" of a particular antibody-antigen interaction as is known in the art.

The term "labeled binding protein" as used herein, refers to a protein with a label incorporated that provides for the identification of the binding protein. Preferably, the label is a detectable marker, e.g., incorporation of a radiolabeled amino acid or attachment to a polypeptide of biotinyl moieties

that can be detected by marked avidin (e.g., streptavidin containing a fluorescent marker or enzymatic activity that can be detected by optical or colorimetric methods). Examples of labels for polypeptides include, but are not limited to, the following: radioisotopes or radionuclides (e.g., ^{3}H, ^{14}C, ^{35}S, ^{90}Y, ^{99}Tc, ^{111}In, ^{125}I, ^{131}I, ^{177}Lu, ^{166}Ho or ^{153}Sm); fluorescent labels (e.g., FITC, rhodamine or lanthanide phosphors), enzymatic labels (e.g., horseradish peroxidase, luciferase or alkaline phosphatase); chemiluminescent markers; biotinyl groups; predetermined polypeptide epitopes recognized by a secondary reporter (e.g., leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains or epitope tags); and magnetic agents, such as gadolinium chelates.

The term "antibody conjugate" refers to a binding protein, such as an antibody, chemically linked to a second chemical moiety, such as a therapeutic or cytotoxic agent. The term "agent" is used herein to denote a chemical compound, a mixture of chemical compounds, a biological macromolecule, or an extract made from biological materials. Preferably, the therapeutic or cytotoxic agents include, but are not limited to, pertussis toxin, taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin, as well as analogs and homologs of these agents.

The terms "crystal", and "crystallized" as used herein, refer to an antibody, or antigen binding portion thereof, that

exists in the form of a crystal. Crystals are one form of the solid state of matter.

The term "immunize" refers herein to the process of presenting an antigen to an immune repertoire whether that repertoire exists in a natural genetically unaltered organism, or a transgenic organism modified to display an artificial human immune repertoire. Similarly, an "immunogenic preparation" is a formulation of antigen that contains adjuvants or other additives that would enhance the immunogenicity of the antigen. An example of this would be co-injection of a purified form of GLP-1 receptor with Freund's complete adjuvant into a mouse. "Hyperimmunization", as defined herein, is the act of serial, multiple presentations of an antigen in an immunogenic preparation to a host animal with the intention of developing a strong immune response.

One way of measuring the binding kinetics of an antibody is by surface plasmon resonance. The term "surface plasmon resonance", as used herein, refers to an optical phenomenon that allows for the analysis of real-time biospecific interactions by detection of alterations in protein concentrations within a biosensor matrix, for example using the Biacore system (Biacore International, Upsala, Sweden and Piscataway, NJ). For further descriptions, see Jönsson *et al.* (1993) Annales de Biologie Clinique (Paris) 51:19-26; Jönsson *et al.* (1991) Biotechniques 11:620-627; Johnsson *et al.* (1995) Journal of Molecular Recognition 8:125-131; and Johnnson *et al.* (1991) Analytical Biochemistry 198:268-277.

A "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents, and the like that are physiologically compatible. Examples of

pharmaceutically acceptable carriers include one or more of water, saline, phosphate buffered saline, dextrose, glycerol, ethanol and the like, as well as combinations thereof. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as mannitol, sorbitol, or sodium chloride in the composition. Pharmaceutically acceptable carriers may further comprise minor amounts of auxiliary substances such as wetting or emulsifying agents, preservatives or buffers, which enhance the shelf life or effectiveness of the antibody or antibody portion.

The pharmaceutical compositions of the invention may include a "therapeutically effective amount" or a "prophylactically effective amount" of an antibody or antibody portion of the invention. A "therapeutically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic result. A therapeutically effective amount of the antibody or antibody portion may be determined by a person skilled in the art and may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the antibody or antibody portion to elicit a desired response in the individual. A therapeutically effective amount is also one in which any toxic or detrimental effects of the antibody or antibody portion are outweighed by the therapeutically beneficial effects. A "prophylactically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired prophylactic result. Typically, since a prophylactic dose is used in subjects prior to or at an earlier stage of disease, the prophylactically effective amount will be less than the therapeutically effective amount.

The antibodies and antibody-portions of the invention can be incorporated into a pharmaceutical composition suitable

for, for example, parenteral administration. Preferably, the antibody or antibody-portions will be prepared as an injectable solution containing 0.1-250 mg/ml antibody. The injectable solution can be composed of either a liquid or lyophilized dosage form in a flint or amber vial, ampule or pre-filled syringe. The buffer can be L-histidine (1-50 mM), optimally 5-10mM, at pH 5.0 to 7.0 (optimally pH 6.0). Other suitable buffers include but are not limited to, sodium succinate, sodium citrate, sodium phosphate or potassium phosphate. Sodium chloride can be used to modify the toxicity of the solution at a concentration of 0-300 mM (optimally 150 mM for a liquid dosage form). Cryoprotectants can be included for a lyophilized dosage form, principally 0-10% sucrose (optimally 0.5-1.0%). Other suitable cryoprotectants include trehalose and lactose. Bulking agents can be included for a lyophilized dosage form, principally 1-10% mannitol (optimally 2-4%). Stabilizers can be used in both liquid and lyophilized dosage forms, principally 1-50 mM L-Methionine (optimally 5-10 mM). Other suitable bulking agents include glycine, arginine, can be included as 0-0.05% polysorbate-80 (optimally 0.005-0.01%). Additional surfactants include but are not limited to polysorbate 20 and BRIJ surfactants.

The compositions of this invention may be in a variety of forms. These include, for example, liquid, semi-solid and solid dosage forms, such as liquid solutions (*e.g.*, injectable and infusible solutions), dispersions or suspensions, tablets, pills, powders, liposomes and suppositories. The preferred form depends on the intended mode of administration and therapeutic application. Typical preferred compositions are in the form of injectable or infusible solutions, such as compositions similar to those used for passive immunization of humans with other antibodies. The preferred mode of administration is parenteral (*e.g.*, intravenous, subcutaneous,

intraperitoneal, intramuscular). In a preferred embodiment, the antibody is administered by intravenous infusion or injection. In another preferred embodiment, the antibody is administered by intramuscular or subcutaneous injection.

Therapeutic compositions typically must be sterile and stable under the conditions of manufacture and storage. The composition can be formulated as a solution, microemulsion, dispersion, liposome, or other ordered structure suitable to high drug concentration. Sterile injectable solutions can be prepared by incorporating the active compound (*i.e.*, antibody or antibody portion) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile, lyophilized powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and spray-drying that yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof. The proper fluidity of a solution can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Prolonged absorption of injectable compositions can be brought about by including, in the composition, an agent that delays absorption, for example, monostearate salts and gelatin.

The antibodies and antibody-portions of the present invention can be administered by a variety of methods known in the art, although for many therapeutic applications, the preferred route/mode of administration is subcutaneous injection, intravenous injection or infusion. As will be

appreciated by the skilled artisan, the route and/or mode of administration will vary depending upon the desired results. In certain embodiments, the active compound may be prepared with a carrier that will protect the compound against rapid release, such as a controlled release formulation, including implants, transdermal patches, and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Many methods for the preparation of such formulations are patented or generally known to those skilled in the art. See, *e.g.*, *Sustained and Controlled Release Drug Delivery Systems*, J.R. Robinson, ed., Marcel Dekker, Inc., New York, 1978.

In certain embodiments, an antibody or antibody portion of the invention may be orally administered, for example, with an inert diluent or an assimilable edible carrier. The compound (and other ingredients, if desired) may also be enclosed in a hard or soft shell gelatin capsule, compressed into tablets, or incorporated directly into the subject's diet. For oral therapeutic administration, the compounds may be incorporated with excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups, wafers, and the like. To administer a compound of the invention by other than parenteral administration, it may be necessary to coat the compound with, or co-administer the compound with, a material to prevent its inactivation.

Supplementary active compounds can also be incorporated into the compositions. In certain embodiments, an antibody or antibody portion of the invention is coformulated with and/or coadministered with one or more additional therapeutic agents that are useful for treating Alzheimer's Disease or related diseases or conditions. For example, one of the antibodies of

the subject invention or antibody portion thereof may be coformulated and/or coadministered with one or more additional antibodies that bind other targets.

In certain embodiments, a monoclonal antibody of the subject invention or fragment thereof may be linked to a half-life extending vehicle known in the art. Such vehicles include, but are not limited to, the Fc domain, polyethylene glycol, and dextran. Such vehicles are described, e.g., in U.S. Application Serial No. 09/428,082 and published PCT Application No. WO 99/25044, which are hereby incorporated by reference for any purpose.

In addition to the above discussed procedures, practitioners are familiar with the standard resource materials which describe specific conditions and procedures for the construction, manipulation and isolation of macromolecules (e.g., DNA molecules, plasmids, etc.), generation of recombinant organisms and the screening and isolating of clones (see for example, Sambrook et al., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press (1989); Maliga et al., Methods in Plant Molecular Biology, Cold Spring Harbor Press (1995); Birren et al., Genome Analysis: Detecting Genes, 1, Cold Spring Harbor, New York (1998); Birren et al., Genome Analysis: Analyzing DNA, 2, Cold Spring Harbor, New York (1998); Plant Molecular Biology: A Laboratory Manual, eds. Clark, Springer, New York (1997)).

Uses of the Monoclonal Antibody

The monoclonal antibodies of the present invention (e.g., 8F5 and 8CF) have many interesting utilities. For example, the monoclonal antibodies may be used in the prevention, treatment and diagnosis of Alzheimer's Disease as described above. Further, the antibodies may be used in the development of anti-antibodies. Further, the hybridoma producing the

respective antibody allows for the steady production of a continuous source of identical monoclonal antibodies (i.e., reagents), thereby guaranteeing identity between antibodies in various experiments as well as therapeutic uses.

Also, the methods of the present invention allow one to prepare appropriate amounts of starting material for use in the preparation of further materials that, in turn, may be utilized in the production of monoclonal antibodies (or other antibodies) for the treatment of Alzheimer's Disease. As noted above, the antibodies may also be used for passive immunization in order to prevent Alzheimer's Disease or other related neurological conditions characterized by the same symptoms as Alzheimer's Disease such as cognitive impairment.

In one diagnostic embodiment of the present invention, an antibody of the present invention (e.g., 8F5), or a portion thereof, is coated on a solid phase (or is present in a liquid phase). The test or biological sample (e.g., whole blood, cerebrospinal fluid, serum, etc.) is then contacted with the solid phase. If antigen (e.g., globulomer) is present in the sample, such antigens bind to the antibodies on the solid phase and are then detected by either a direct or indirect method. The direct method comprises simply detecting presence of the complex itself and thus presence of the antigens. In the indirect method, a conjugate is added to the bound antigen. The conjugate comprises a second antibody, which binds to the bound antigen, attached to a signal-generating compound or label. Should the second antibody bind to the bound antigen, the signal-generating compound generates a measurable signal. Such signal then indicates presence of the antigen in the test sample.

Examples of solid phases used in diagnostic immunoassays are porous and non-porous materials, latex particles, magnetic particles, microparticles (see e.g., U.S. Patent No.

5,705,330), beads, membranes, microtiter wells and plastic tubes. The choice of solid phase material and method of labeling the antigen or antibody present in the conjugate, if desired, are determined based upon desired assay format performance characteristics.

As noted above, the conjugate (or indicator reagent) will comprise an antibody (or perhaps anti-antibody, depending upon the assay), attached to a signal-generating compound or label. This signal-generating compound or "label" is itself detectable or may be reacted with one or more additional compounds to generate a detectable product. Examples of signal-generating compounds include chromogens, radioisotopes (e.g., 125I, 131I, 32P, 3H, 35S and 14C), chemiluminescent compounds (e.g., acridinium), particles (visible or fluorescent), nucleic acids, complexing agents, or catalysts such as enzymes (e.g., alkaline phosphatase, acid phosphatase, horseradish peroxidase, beta-galactosidase and ribonuclease). In the case of enzyme use (e.g., alkaline phosphatase or horseradish peroxidase), addition of a chromo-, fluro-, or lumo-genic substrate results in generation of a detectable signal. Other detection systems such as time-resolved fluorescence, internal-reflection fluorescence, amplification (e.g., polymerase chain reaction) and Raman spectroscopy are also useful.

Examples of biological fluids which may be tested by the above immunoassays include plasma, whole blood, dried whole blood, serum, cerebrospinal fluid or aqueous or organo-aqueous extracts of tissues and cells.

The present invention also encompasses a method for detecting the presence of antibodies in a test sample. This method comprises the steps of: (a) contacting the test sample suspected of containing antibodies with anti-antibody specific for the antibodies in the patient sample under time and

conditions sufficient to allow the formation of anti-antibody/antibody complexes, wherein the anti-antibody is an antibody of the present invention which binds to an antibody in the patient sample; (b) adding a conjugate to the resulting anti-antibody/antibody complexes, the conjugate comprising an antigen (which binds to the anti-antibody) attached to a signal generating compound capable of detecting a detectable signal; and (d) detecting the presence of the antibodies which may be present in the test sample by detecting the signal generated by the signal generating compound. A control or calibrator may be used which comprises antibody to the anti-antibody.

The present invention also includes a vaccine comprising one of more of the antibodies described herein or a portion thereof and a pharmaceutically acceptable adjuvant (e.g., Freund's adjuvant or phosphate buffered saline).

Kits are also included within the scope of the present invention. More specifically, the present invention includes kits for determining the presence of antigens (e.g., globulomers) in a patient suspected of having Alzheimer's Disease or another condition characterized by cognitive impairment. In particular, a kit for determining the presence of antigens in a test sample comprises a) an antibody as defined herein or portion thereof; and b) a conjugate comprising a second antibody (having specificity for the antigen) attached to a signal generating compound capable of generating a detectable signal. The kit may also contain a control or calibrator which comprises a reagent which binds to the antigen as well as an instruction sheet detailing how the kit is to be utilized and the components of the kit.

The present invention also includes a kit for detecting antibodies in a test sample. The kit may comprise a) an anti-antibody specific (for example, one of the subject invention)

for the antibody of interest, and b) an antigen or portion thereof as defined above. A control or calibrator comprising a reagent which binds to the antigen may also be included. More specifically, the kit may comprise a) an anti-antibody (such as the one of the present invention) specific for the antibody and b) a conjugate comprising an antigen (e.g., globulomer) attached to a signal generating compound capable of generating a detectable signal. Again, the kit may also comprise a control of calibrator comprising a reagent which binds to the antigen and may also comprise an instruction sheet or package insert describing how the kit should be used and the components of the kit.

The kit may also comprise one container such as vial, bottles or strip, with each container with a pre-set solid phase, and other containers containing the respective conjugates. These kits may also contain vials or containers of other reagents needed for performing the assay, such as washing, processing and indicator reagents.

It should also be noted that the subject invention not only includes the full length antibodies described above but also portions or fragments thereof, for example, the Fab portion thereof. Additionally, the subject invention encompasses any antibody having the same properties of the present antibodies in terms of, for example, binding specificity, structure, etc.

Deposit Information: The hybridoma (ML5-8F5.1F2.2A2) which produces monoclonal antibody 8F5 was deposited with the American Type Culture Collection, 10801 University Boulevard, Manassas, Virginia 20110 on December 1, 2005 under the terms of the Budapest Treaty and was assigned ATCC No. PTA-7238.

Hybridoma (ML5-8C5.2C1.8E6.2D5) which produces monoclonal antibody 8C5 was deposited with the American Type Culture

Collection, 10801 University Boulevard, Manassas, Virginia 20110 on February 28, 2006 under the terms of the Budapest Treaty and was assigned ATCC No: PTA-7407.

The present invention may be illustrated by use of the following non-limiting examples:

EXAMPLE I(a)

PRODUCTION OF MONOCLONAL ANTIBODIES 8F5 AND 8C5

Balb/c mice were immunized sub-q with 50 microgram of A-beta (1-42)globulomer as described in Barghorn et al., 2005, J Neurochem, 95, 834-847 in CFA (Sigma) and boosted twice at one month intervals. Spleens were collected and spleen cells fused with mouse myeloma SP2/0 cells at 5:1 ratio by a PEG procedure. Fusion cells were plated in 96-well dishes in Azaserine/Hypoxanthine selection media at $2x10^5$ cells/ml, 200 ml per well. Cells were allowed to grow to form visible colonies and supernatants assayed for A-beta oligomer reactivity by a direct ELISA assay. Hybridomas secreting antibodies to A-beta oligomers were subcloned by limiting dilution, until antibody expression appeared stable.

EXAMPLE II

8F5 AND 8C5 PREFERENTIAL GLOBULOMER BINDING COMPARED TO MONOMER PREPARATIONS OF AB(1-40) AND AB(1-42)

To test the selectivity of 8F5, two differently dissolved Aß(1-42) monomer preparations were used as well as freshly prepared Aß(1-40) as surrogates for monomers. Two types of experiments were performed. In a first experiment, 8F5 was tested for Aß globulomer selectivity by a Sandwich-ELISA with globulomer derived but conformer non-specific MAb 6G1 (see S. Barghorn et al. J. Neurochemistry, 95:834 (2005)) as a capture

antibody. Biotinylated 8F5 was used as the second and conformer selective antibody. This experiment is described in Example 2.1 below.

In a second example, described in Example 2.2 below, the oligomer selectivity versus Aß(1-42) monomer and Aß(1-40) monomer was examined by dot blot immunoassay. In this experiment, 8F5 exhibited preferential binding to Aß(1-42) globulomer (compared to a known antibody 4G8 mapping to a similar region as 8F5, but derived from immunization with a linear peptide Aβ(17-24) (Abcam Ltd., Cambridge, MA)), as compared to Aß(1-42) monomer as well as compared to Aß(1-40) monomer. 8C5 was tested in an identical protocol to 8F5.

EXAMPLE 2.1: OLIGOMER SELECTIVITY OF MONOCLONAL ANTIBODY 8F5 AND 8C5

a) Preparation of Aß(1-42) globulomer:

9 mg Aß(1-42) Fa. Bachem were dissolved in 1.5ml HFIP (1.1.1.3.3.3 Hexafluor-2-propanol) and incubated 1,5 h at 37°C. The solution was evaporated in a SpeedVac and suspended in 396 μl DMSO (5mM Aß stock solution). The sample was sonified for 20 seconds in a sonic water bath, shaken for 10 minutes and stored over night at -20°C.

The sample was diluted with 4.5 ml PBS (20 mM NaH2PO4; 140 mM NaCl; pH 7,4) and 0.5 ml 2 % aqueous SDS-solution were added (0.2% SDS content). The mixture was incubated for 7 h at 37°C, diluted with 16 ml H_2O and further incubated for 16 hours at 37 deg C. After that, the Aß(1-42) globulomer solution was centrifuged for 20min at 3000g. The supernatant was concentrated to 0.5ml by 30KDa centriprep. The concentrate

was dialysed against 5mM NaH2PO4; 35mM NaCl; pH7.4 overnight at 6°C. Subsequently, the Aß(1-42) globulomer concentrate was centrifuged for 10min at 10000g. The supernatant was then aliquoted and stored at -20°C.

b) Preparation of monomer Aß(1-42), HFIP pretreated:

3mg human Aß(1-42),(Bachem Inc) cat. no. H-1368 were dissolved in 0.5ml HFIP (6mg/ml suspension) in an 1.7 ml Eppendorff tube and was shaken (Eppendorff Thermo mixer, 1400 rpm) for 1.5h at 37°C till a clear solution was obtained. The sample was dried in a speed vac concentrator (1.5h) and resuspended in 13.2µl DMSO, shook for 10 sec., followed by ultrasound bath sonification (20 sec) and shaking (e.g. in Eppendorff Thermo mixer, 1400 rpm) for 10 min.

6ml 20mM NaH2PO4; 140mM NaCl; 0.1% Pluronic F68; pH 7.4 was added and stirred for 1h at room temperature. The sample was centrifuged for 20min at 3000g. The supernatant was discarded and the precipitate solved in 0.6ml 20mM NaH2PO4; 140mM NaCl; 1% Pluronic F68; pH 7.4. 3.4ml water was added and stirred for 1h at room temperature followed by 20 min centrifugation at 3000 g. 8 x 0.5ml aliquots of the supernatant were stored at -20°.

c) Preparation of monomer Aß(1-42) in NH_4OH :

1mg Aß(1-42) solid powder (Bachem Inc. cat. no. H-1368) was dissolved in 0.5ml 0.1% NH_4OH in water (freshly prepared)(2mg/ml) and immediately shaken for 30 sec. at room temperature to get a clear solution. The sample was stored at -20°C for further use.

d) Preparation of monomer Aß(1-40):

1mg human Aß(1-40), (Bachem Inc) cat. no. H-1194 was suspended in 0.25ml HFIP (4mg/ml suspension) in an Eppendorff tube. The tube was shaken (e.g., in an Eppendorff Thermo mixer, 1400 rpm) for 1.5h at 37°C to get a clear solution and afterwards dried in a speed vac concentrator(1.5h). The sample was redissolved in 46µl DMSO (21.7 mg/ml solution), shaken for 10 sec., followed by 20 sec. sonification in ultrasound bath. After 10 min of shaking (e.g. in Eppendorff Thermo mixer, 1400 rpm), the sample was stored at -20°C for further use.

e) Biotinylation of anti-Aß mouse Mab 8F5:

500µl anti-Aß mouse Mab 8F5 (0.64mg/ml) in PBS were added to 2µl 20mg/ml Sulfo-NHS-Biotin (Pierce Inc. cat.no. 21420) freshly dissolved in water and shaken (e.g. in Eppendorff Thermo mixer, 1400 rpm), for 30 min, dialyzed 16h at 6°C in a dialysis tube against 500ml 20mM Na Pi; 140mM NaCl; pH 7.4. The dialysate was stored at -20°C for further use. 8C5 was biotinylated accordingly.

f) Sandwich-ELISA for Aß-samples:

g) Reagent List:

1. F96 Cert. Maxisorp NUNC-Immuno Plate Cat.No.: 439454
2. Binding antibody:
   Anti-Aß mouse MAb 6G1, solved in PBS; conc.: 0.4mg/ml; store at -20°C
3. Coating-Buffer:
   100mM Sodiumhydrogencarbonate; pH 9.6

4. Blocking Reagent for ELISA; Roche Diagnostics GmbH Cat. No.: 1112589
5. PBST-Buffer:
   20mM NaH2PO4; 140mM NaCl; 0.05% Tween 20; pH 7.4
6. Albumin bovine fraction V, protease-free; Serva Cat.No.: 11926.03; store at 4°C.
7. PBST + 0.5% BSA-Buffer:
   20mM NaH2PO4; 140mM NaCl ; 0.05% Tween 20; pH 7.4 + 0.5% BSA
8. Aß(1-42)-globulomer Standard Stock:
   solution in 5mM NaH2PO4 ; 35mM NaCl; pH7.4; conc.: 10.77mg/ml; store at -20°C
9. Aß(1-42) monomer HFIP treated Standard Stock:
   solution in 3mM NaH2PO4; 21mM NaCl; 0.15% Pluronic F68; pH 7.4; conc.: 0.45mg/ml; store at -20°C
10. Aß(1-42) monomer in NH4OH Standard Stock; solution in 0.1% NH_4OH conc.: 2mg/ml; store at -20°C
11. Aß(1-40) monomer HFIP treated Standard Stock; solution in DMSO; conc.: 21.7mg/ml; store at -20°C
12. biotinylated anti-Aß mouse mAb clone 8F5; solution in PBS; conc.: 0.24mg/ml; store at -80°C
13. Streptavidin-POD conjugate; Fa.Roche Cat. No.: 1089153
14. staining:
    TMB; Roche Diagnostics GmbH Cat.No.: 92817060; 42mM in DMSO; 3% H_2O_2 in water; 100mM sodium acetate pH 4.9
15. Stop staining by adding 2M Sulfonic Acid solution

Preparation of reagents:

The following protocol was utilized:

1. Binding antibody

Thaw mMAb 6G1 stock solution and dilute 1:400 in coating buffer.

2. Blocking reagent:

Dissolve blocking reagent in 100ml water to prepare the blocking stock solution and store aliquots of 10ml at -20°C. Dilute 3ml blocking stock solution with 27ml water for each plate to block.

3. Aß Standard solutions:

a) Aß(1-42)-globulomer

- Add 1µl Aß(1-42)-globulomer standard stock solution to 1076µl PBST + 0.5% BSA = 10µg/ml
- Add 50µl 10µg/ml Aß(1-42)-globulomer standard solution to 4950µl PBST + 0.5% BSA = 100ng/ml

b) Aß(1-42) monomer HFIP-treated

- Add 10µl Aß(1-42) monomer HFIP-pretreated standard stock solution to 440µl PBST + 0.5% BSA = 10µg/ml
- Add 50µl 10µg/ml Aß(1-42) monomer HFIP pretreated standard solution to 4950µl PBST + 0.5% BSA = 100ng/ml

c) Aß(1-42) monomer in NH4OH

- Add 5µl Aß(1-42) monomer in NH4OH standard stock solution to 995µl PBST + 0.5% BSA = 10µg/ml
- Add 50µl 10µg/ml Aß(1-42) monomer in NH4OH standard solution to 4950µl PBST + 0.5% BSA = 100ng/ml

d) Aß(1-40) monomer HFIP-pretreated

- Add 1µl Aß(1-40) monomer HFIP pretreated standard stock solution to 49µl PBST + 0.5% BSA = 430µg/ml

- Add 10μl 430μg/ml Aß(1-40) monomer HFIP pretreated standard solution to 420μl PBST + 0.5% BSA = 10μg/ml
- Add 50μl 10μg/ml Aß(1-40) monomer HFIP pretreated standard solution to 4950μl PBST + 0.5% BSA = 100ng/ml

Standard curves:

No Final Conc.	Stock	PBST + 0.5% BSA
1 100ng/ml	2ml S	0 ml
2 31.6ng/ml	0.633ml (1)	1.367ml
3 10ng/ml	0.633ml (2)	1.367ml
4 3.16ng/ml	0.633ml (3)	1.367ml
5 1ng/ml	0.633ml (4)	1.367ml
6 0.32ng/ml	0.633ml (5)	1.367ml
7 0.1ng/ml	0.633ml (6)	1.367ml
8 0.0ng/ml	0ml	2ml

1. Primary antibody: biotinylated mMAb 8F5:
The concentrated biotinylated anti-Aß mAb 8F5 was diluted in PBST + 0.5% BSA-buffer. The dilution factor was 1/1200 = 0.2μg/ml. The antibody was used immediately.

2. Label Reagent:
Reconstitute Streptavidin-POD conjugate lyophilizate in 0.5ml water. Add 500µl glycerol and store aliquots of 100µl at -20°C for further use.
Dilute the concentrated label reagent in PBST-Buffer. The dilution factor is 1/10000. Use immediately.

3. Staining Solution TMB:
Mix 20ml 100mM sodium acetate pH 4.9 with 200µl of the TMB solution and 29.5µl 3% peroxide solution. Use immediately.

Sample Plate Setup: (Note that all standards are run in duplicate)

	1	2	3	4	5	6	7	8	9	10	11	12
A	100	100	100	100	100	100	100	100	100	100	100	100
B	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
C	10	10	10	10	10	10	10	10	10	10	10	10
D	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16
E	1	1	1	1	1	1	1	1	1	1	1	1
F	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
G	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Procedure Utilized:

1. Apply 100µl anti-Aß mMAb 6G1 solution per well and incubate overnight at 4°C.

2. Discard the antibody solution and wash the wells with 250µl PBST-Buffer three times.

3. Add 260µl block solution per well and incubate 2h at room temperature.

4. Discard the block solution and wash the wells with 250µl PBST-Buffer three times.

5. After preparation of standards, apply 100µl per well of standards to the plate. Incubate 2h at room temperature and overnight at 4°C.

6. Discard the standard solution and wash the wells with 250µl PBST-Buffer three times.

7. Add 200µl primary biotinylated antibody 8F5 solution per well and incubate 1.5h at room temperature.

8. Discard the antibody solution and wash the wells with 250µl PBST-Buffer three times.

9. Add 200µl label solution per well and incubate 1h at room temperature.

10. Discard the label solution and wash the wells with 250µl PBST-Buffer three times.

11. Add 100µl of TMB solution to each well and incubate at room temperature (5-15min).

12. Observe staining and apply 50µl of the Stop Solution per well after beginning of background staining.

13. UV-read at 450nm.

14. Calculate results from standard curve.

15. Evaluation

The results are shown in Fig. 1 for the antibody 8F5 and in Fig. 8 for the antibody 8C5. Log EC50 values are significantly lowest for the Aß(1-42) globulomer antigen (1.958) compared to reduced values for two differently prepared Aß (1-42) monomers (2.745 and 3.003 respectively)and Aß(1-40)monomer (2.825). These data indicate about 10 fold

selectivity of antibody 8F5 for Aß (1-42) globulomer versus Aß (1-42)monomer.

Almost identical results were obtained with antibody 8C5 and are shown in Fig. 8.

EXAMPLE 2.2: OLIGOMER SELECTIVITY OF MONOCLONAL ANTIBODY 8F5 AND 8C5

-Discrimination of Aβ monomer against Aβ globulomer by dot blot method: Comparison of 8F5 and 8C5 versus 4G8.

Serial dilutions of Aβ(1-42) globulomer, Aβ1-42 monomer and Aβ1-40 monomer were made in the range from 100pmol/μl-0.01pmol/μl in PBS. Of each sample, 1μl was dotted onto a nitrocellulose membrane. The mouse monoclonal antibodies 4G8 and 8F5 (0.2 μg/ml) were used for detection with an anti-mouse IgG coupled to alkaline phosphatase as secondary antibody and the staining reagent NBT/BCIP (Roche Diagnostics, Mannheim). The detection signal was analyzed in its intensity (reflective density = RD) via a densitometer (GS 800, Biorad, Hercules, CA, USA) at an antigen concentration of 10pmol. At this concentration for every Aβ-form, the measured reflective density was in the linear range of the densitometer detection. The other antibody 8C5 was used in an analogous protocol. The results are shown in Table 1 below:

	Reflective Density (RD) [10pmol]				
	Aß(1-42) globulomer	Aß(1-42) monomer	Aß(1-40) monomer	Ratio RD Aß(1-42) globulomer / RD Aß(1-42) monomer	Ratio RD Aß(1-42) globulomer / RD Aß(1-40) monomer
8F5	1,6	1,1	0,1	1,4	16,9
8C5	1,3	0,2	0,3	5,1	4,1

4G8	3	3,1	0,7	1	4,2

Table 1: Discrimination of anti-Aβ-antibodies of Aβ1-40 monomer and Aβ1-42 monomer. The discrimination was calculated as the ratio of detection signal of Aβ1-42 globulomer and Aβ1-42 monomer, respectively Aβ1-40 monomer.

In particular, the above results indicate that 8F5_and 8C5 show a different binding profile compared to commercially available anti-Aβ(1-42) antibody to 4G8, which maps to Aβ (17-24)(i.e., a linear sequence). More specifically, 8F5 and 8C5 show a preference for globulomer binding versus Aβ42 monomer (see column 4; compare 1.4 versus 1) as well as a preference for globulomer binding versus Aβ40 (column 5; compare 16.9 versus 4.2). These two improved binding selectivities over standard 4G8 should result in the production of fewer side effects upon use of 8F5 and/or 8C5, as described above (e.g., plaque binding).

EXAMPLE III

BINDING OF 8F5 AND 8C5 TO Aß(1-42) FIBRILS

Since 8F5 antibody was generated against soluble globulomers, it was hypothesized that 8F5 should not bind to deposited plaque or fibril material. Therefore, binding of 8F5 to polymerized Aß fibril suspensions was tested as described in the following example:

- Preparation of Aß(1-42) fibrils:

1mg Aß(1-42) (Bachem Inc., Catalog Nr.: H-1368) was dissolved in 500µl aqueous 0.1% NH_4OH (Eppendorff tube), and the sample was stirred for 1min at room temperature followed by 5 min centrifugation at 10000 g. Supernatant was pipetted into a new Eppendorff tube and the Aß(1-42) concentration measured

according to Bradford protein concentration assay (BIO-RAD Inc. assay procedure).

100μl of this freshly prepared Aß(1-42) solution were neutralized with 300μl 20mM NaH2PO4; 140mM NaCl; pH 7.4 followed by 2% HCl to adjust pH 7.4. The sample was incubated for another 20 hrs at 37°C and centrifuged (10min, 10000g). The supernatant was discarded and the fibril pellet resuspended with 400μl 20mM NaH2PO4; 140mM NaCl; pH 7.4 under 1 min stirring on a Vortex mixer followed by centrifugation (10min, 10000g). After discarding the supernatant, this resuspending procedure was repeated, and the final fibril suspension spun down by another centrifugation (10min, 10000g). The supernatant was once again discarded and the final pellet resuspended in 380μl 20mM NaH2PO4; 140mM NaCl; pH7.4 under 1 min stirring on a Vortex mixer. Aliquots of the sample were stored at -20°C in a freezer.

80μl fibril suspension were mixed with 320μl 20mM NaH2PO4; 140mM NaCl; 0.05% Tween 20; pH 7.4, buffer and stirred for 5min at room temperature followed by sonification (20 sec). After centrifugation (10min, 10000g), the pellet was resuspended with 190μl 20mM NaH2PO4; 140mM NaCl; 0.05% Tween 20; pH 7.4 under stirring in a Vortex mixer.

- <u>Binding of Antibodies to Aß(1-42) fibrils</u>

10μl aliquots of this fibril suspension was incubated with:

a) 10μl 20mM Na Pi; 140mM NaCl; pH 7.4
b) 10μl 0.1μg/μl mMAb 6E10 Signet Inc. Cat.#9320 in 20mM
c) NaH2PO4; 140mM NaCl; pH 7.4
d) 10μl 0.1μg/μl mMAb 4G8 SignetInc. Cat# 9220 in 20mM Na Pi; 140mM NaCl; pH 7.4

e) 10µl 0.1µg/µl mMAb 8F5 (8C5) in 20mM Na Pi; 140mM NaCl; pH 7.4

Samples were incubated for 20h at 37°C. Finally the samples were centrifuged (10 min at 10000g). The supernatants containing the unbound antibody fraction were collected and mixed with 20 µl SDS-PAGE sample buffer. The pellet fractions were washed with 50µl 20mM NaH2PO4; 140mM NaCl; pH 7.4 buffer under 1 min stirring in a Vortex mixer followed by centrifugation (10min, 10000g). The final pellets were resuspended in 20µl 20mM Na Pi; 140mM NaCl; 0.025% Tween 20; pH 7.4 buffer and solved in 20µl SDS-PAGE buffer.

-SDS-PAGE analysis

Supernatants and resuspended pellet samples were heated for 5 min at 98°C and loaded onto a 4-20% Tris/Glycin Gel under the following conditions:

SDS-sample buffer: 0.3g SDS; 0.77g DTT; 4ml 1M Tris/HCl pH 6.8; 8ml glycerol; 1ml 1% Bromphenolblue in Ethanol; add water to 50 ml 4-20% Tris/Glycin Gel:Invitrogen Inc., No.: EC6025BOX

running buffer: 7.5g Tris; 36g Glycine; 2.5g SDS; add water to 2.5l

The PAGE was run at 20 mA. Gels were stained by Coomassie Blue R250.

Results:

Coomassie staining of SDS-PAGE indicated the presence of heavy and light chains of antibodies predominantly in the

supernatant of the fibril suspension (lane 7, Figure 2), the remaining fibril suspension showed very little antibody material while also showing partly depolymerized Abeta at 4.5 kDa. In contrast to 8F5 and 8C5, other anti-Aß antibodies did not show up in the soluble fraction (6E10, lane 3, Figure 2) or only partly (4G8, lane 5, Figure 2) compared to fibril bound fraction (lane 6, Figure 2).

The relative binding to fibril type Abeta was evaluated from SDS-PAGE analysis by measuring the Reflective Density values from the heavy chain of the antibodies in the fibril bound and the supernatant fractions and calculated according to the following formula:

Fibril bound Ab fraction = $RD_{\text{fibril faction}}$ x100%/($RD_{\text{fibril faction}}$ + $RD_{\text{supernatant fraction}}$).

The following values were obtained:

antibody	Fibril bound Ab fraction
6E10	98%
8F5	16%
8C5	21%

These data indicate a significant reduction of bound 8F5 and 8C5 compared to standard antibody 6E10.

EXAMPLE IV

PREFERENTIAL BINDING OF ENDOGENOUS Aß(1-42) GLOBULOMERS COMPARED TO Aß(1-40)

Based upon the oligomer concept of Aß, it is important that anti-Aß oligomer antibodies also can demonstrate

preferential binding for Aß (1-42) oligomers *in vivo*, in particular, over Aß(1-40)in Mild Cognitive Impairment and AD patients. The concept of lowering Aß(1-42) species over Aß(1-40) is used in a therapeutic approach for the treatment of AD via NSAIDs (Weggen et al., *Nature* 414, 212-216 (2001)). It is assumed that those NSAIDs which lower Aß(1-42) in relation to Aß(1-40) display the best efficacy in the treatment of Alzheimer Disease. The Aß(1-42)/Aß(1-40)ratio is important for a selective therapy as well as for diagnostic purposes.

An analysis was performed with CSF samples from Alzheimer's Disease patients and patients with MCI. From the results shown in Figure 3 and described below, it can be concluded that 8F5 has a major advantage over Aß antibodies like 6E10 because 8F5 detects a higher ratio of Aß(1-42) over less aggregating Aß(1-40). This advantage will allow one to more selectively diagnose and neutralize Aß(1-42) type oligomers in MCI and AD patients.

A) ENDOGENOUS AMYLOID ß(1-42) AND AMYLOID ß(1-40) LEVELS IN CSF OF MCI AND AD PATIENTS AFTER IMMUNOPRECIPITATION WITH OLIGOMER SELECTIVE ANTI-Aß MURINE MAB 8F5:

Immobilization of anti-Aß mMAB~s to CNBr-activated Sepharose 4B:

a) mMAb 6E10 Signet Inc., Cat.no. 9320
b) mMAb 8F5

0.4g CNBr-activated Sepharose 4B (Amersham Pharmacia Bio-tech AB, Uppsala, Sweden, Inc., No.: 17-0430-01) were added to 10ml aqueous 1mM HCl and incubated for 30min at room temperature. The CNBr-activated Sepharose 4B was washed three times with 10ml 1mM HCl and twice with 10ml 100mM $NaHCO_3$; 500mM NaCl; pH 8.3. For each of the immobilized antibodies, 100μl CNBr-activated Sepharose 4B Matrix were added to 950μl 0.5mg/ml

anti-Aß mMAb solution in 100mM $NaHCO_3$; 500mM NaCl; pH 8.3. After 2 h of shaking at room temperature, samples were centrifuged for 5min at 10000g. Then, 500µl 100mM Ethanolamine; 100mM $NaHCO_3$; 500mM NaCl; pH 8.3, buffer was added to the beads, and samples were shaken for 1h at room temperature. The anti-Aß mMAb-Sepharose samples were centrifuged for 5min at 10000g and washed 5 times with 500µl 20mM NaH2PO4; 140mM NaCl; pH 7.4. Before storage at 6°C, samples were stabilized by adding sodium azide to 0.02% final concentration.

Immunoprecipitation:

a) mMAb 6E10-Sepharose
b) mMAb 8F5 -Sepharose

200µl of the human Cerebral Spinal Fluid samples were diluted with 200µl 20mM NaH2PO4NaH_2PO_4; 140mM NaCl; 0.05% Tween 20; pH 7.4. These samples were added to 2µl anti-Aß mMAb-Sepharose Matrix and stirred for 2h at room temperature. The samples were centrifuged for 5min at 10000g. The supernatants were discarded and the anti-Aß mMAb-Sepharose washed twice with 50µl PBS, stirred for 1min and centrifuged (5min at 10000g). The supernatants were discarded, and the Sepharose beads were now suspended in 50µl 2mM NaH_2PO_4NaH2PO4; 14mM NaCl, pH7.4, followed by 1min of stirring at room temperature and 5min of centrifugation at 10000g. In a next step, the anti-Aß mMAb-Sepharose beads were treated with 50µl 50% CH_3CN; 0.2% TFA in water. After 10min shaking at room temperature, samples were centrifuged 5min at 10000g. The supernatants were collected and transferred to 1.5ml Eppendorf tubes. Samples were mixed with 50µl water and evaporated in a Speed Vac concentrator.

The pellet was redissolved in 4µl 70% HCOOH, shaken for 10min at room temperature and neutralized with 76µl 1M Tris-solution and 720µl 20mM NaH_2PO_4NaH2PO4; 140mM NaCl; 0.05% Tween 20; pH 7.4.

Samples for the Determination of Aß(1-40); (1-42) Monomer Forms in CSF:

a) Aß-content in CSF-samples without immunoprecipitation:

158µl CSF were diluted with 342µl 20mM NaH_2PO_4; 140mM NaCl; 0.05% Tween 20; pH 7.4. This 1:3.16 dilution was taken for Sandwich ELISA´s and taken into account during evaluation.

b) Aß-content in CSF-samples after immunoprecipitation:

Samples from the above-mentioned procedure were taken for analysis.

Sandwich-ELISA Protocol Used for the Determination of Aß(1-40) in CSF

Reagent List:

1. F96 Cert. Maxisorp NUNC-Immuno Plate Cat.No.: 439454
2. Binding antibody
   Anti-Aß mAb clone 6E10; Signet Cat.No. 9320; conc.: 0.4mg/ml Bradford (BioRad); store at -20°C
3. Coupling-buffer
   100mM sodiumhydrogencarbonate; pH9.6

4. Blocking Reagent for ELISA; Roche Diagnostics GmbH
   Cat.No.: 1112589
5. PBST-buffer
   20mM NaH_2PO_4NaH2PO4; 140mM NaCl; 0.05% Tween 20; pH7.4
6. Aß(1-40) Standard:
   Aß(1-40) solid powder; Bachem Cat.No.: H-1194; store at -20°C
7. Primary antibody:
   anti-Aß (1-40) rabbit pAb; affinity purified; solution in PBS; conc.: 0.039mg/ml ;
   Signet Cat.No. 9130-005; store at -20°C
8. Label reagent:
   anti-rabbit-POD conjugate; Fa.Jackson ImmunoResearch
   Cat.No.: 111-036-045;
9. Staining:
   TMB; Roche Diagnostics GmbH Cat.No.: 92817060; 42mM in DMSO; 3% H_2O_2 in water; 100mM sodium acetate
   pH 4.9

10. Stop Solution 2M Sulfonic Acid

<u>Protocols Used For Preparation of Reagents:</u>

1. Binding antibody:
   anti-Aß mAb 6E10 (Signet Inc, Catalog # 9320) is diluted to a final concentration of 0.7 microg/ml.

2. Blocking reagent:
   For preparation of the blocking stock solution the blocking reagent is dissolved in 100 ml H_2O and stored at -20 °C in aliquots of 10 ml each. 3 ml of the blocking stock solution are diluted with 27 ml H_2O for blocking one ELISA plate.

3. Aß(1-40) monomer form standard dilution:

A) Aß(1-40) monomer Standard Stock: dissolve 0.5mg Aß(1-40) in 250µl 0.1%NH_4OH, conc.: 2mg/ml ; freshly prepared; use immediately.

B) Add 5µl Aß(1-40)-monomer standard stock solution to 995µl PBST = 10µg/ml

C) Add 5µl, 10µg/ml Aß(1-40)-monomer standard solution to 4995µl PBST = 10ng/ml

Standard curve:

No Final conc.	Stock	PBST
1 10000pg/ml	2ml B	0ml
2 3160pg/ml	0.633ml (1)	1.367ml
3 1000pg/ml	0.633ml (2)	1.367ml
4 316pg/ml	0.633ml (3)	1.367ml
5 100pg/ml	0.633ml (4)	1.367ml
6 31.6pg/ml	0.633ml (5)	1:367ml
7 10pg/ml	0.633ml (6)	1.367ml
8 0.0pg/ml	0ml	2ml

Samples:

IP : immunoprecipitate samples

No dilution factor	sample	PBST
1 directly	0.4ml IP	0ml
2 1:5	0.1ml (1)	0.4ml
3 1:25	0.1ml (2)	0.4ml
4 1:125	0.1ml (3)	0.4ml

4. Primary antibody:
   Dilute the concentrated anti-Aß (1-40) pAb in PBST buffer. The dilution factor is 1/200 = 0.2µg/ml. Use immediately.

5. Secondary antibody:
   Lyophilized anti-rabbit-POD conjugate is dissolved in 0.5 ml H_2O and mixed with 500 µl glycerol. The antibody concentrate is then stored at -20 °C in aliquots of 100 µl. The concentrate is diluted 1:10'000 in PBST buffer. The antibody solution is used immediately.

6. TMB solution:
   20 ml of 100 mM sodium acetate, pH 4.9, are mixed with 200 µl TMB solution and 29.5 µl of 3% hydrogen peroxide. This solution is used immediately.

Sample Plate Setup: (Note that all standards and samples are run in duplicate.)

	1	2	3	4	5	6	7	8	9	10	11	12
A	10000	10000	U1	U1								
B	3160	3160	U2	U2								

C	1000	1000	U3	U3								
D	316	316	U4	U4								
E	100	100	U5	U5								
F	31.6	31.6	U6	U6								
G	10	10	U7	U7								
H	0.0	0.0	U8	U8								

U1-U# = Unknown samples

Procedure Used:

1. Apply 100μl binding antibody solution per well and incubate overnight at 4°C.
2. Discard the antibody solution and wash the wells with 250μl PBST-buffer for three times.
3. Add 260μl block solution per well and incubate 2h at room temperature.
4. Discard the block solution and wash the wells with 250μl PBST-buffer for three times.
5. After preparation of standards and samples, apply 100μl per well of standards and samples to the plate and incubate 2h at room temperature and overnight at 4°C.
6. Discard the standard/sample solution and wash the wells with 250μl PBST-buffer for three times.
7. Add 200μl primary antibody solution per well and incubate 1.5h at room temperature.
8. Discard the antibody solution and wash the wells with 250μl PBST-buffer for three times.
9. Add 200μl label solution per well and incubate 1h at room temperature.
10. Discard the label solution and wash the wells with

250µl PBST-buffer for three times.

11. Add 100µl of TMB solution to each well and incubate at room temperature (5-15min).
12. Observe colour development and apply 50µl of the Stop solution per well.
13. Read at 450nm.
14. Calculate results from standard curve.
15. Evaluation:

If extinction from unknown samples is not in the linearity range of the calibration curve, repeat ELISA with appropriated sample dilution.

Sandwich-ELISA Protocol Used for the Determination of Aß(1-42) Monomer Form in CSF

Reagent List:

1. F96 Cert. Maxisorp NUNC-Immuno Plate Cat.No.:439454
2. Binding antibody
   Anti-Aß mAb clone 6E10 ; Signet Cat.No. 9320 ; conc.: 0.4mg/ml Bradford (BioRad) ; store at -20°C
3. Coating-Buffer
   100mM sodiumhydrogencarbonate; pH9.6
4. Blocking Reagent for ELISA; Roche Diagnostics GmbH Cat.No.: 1112589
5. PBST-Buffer
   20mM NaH2PO4NaH2PO4; 140mM NaCl; 0.05% Tween 20 ; pH7.4
6. Aß(1-42) Standard:
   Aß(1-42) solid powder; Bachem Cat.No.: H-1368; store at -20°C
7. Primary antibody:

anti-Aß (1-42) rabbit pAb; affinity purified; biotinylated ; solution in PBS with 50% glycerol; conc.: 0.25mg/ml; Signet Cat.No. 9137-005; store at -20°C

8. Label reagent:
anti-rabbit-POD conjugate; Fa. Jackson ImmunoResearch Cat.No.: 111-036-045

9. Staining:
TMB; Roche Diagnostics GmbH Cat. No.: 92817060;
42mM in DMSO
3% H_2O_2 in water
100mM sodium acetate, pH4.9
Stop Solution: 2M Sulfonic Acid

Method Used In Preparation of Reagents:

1. Binding antibody:
Dilute anti-Aß mAb clone 6E10 1:400 in coating buffer.

2. Blocking reagent:
Dissolve blocking reagent in 100ml water to prepare the blocking stock solution and store aliquots of 10ml at -20°C. Dilute 3ml blocking stock solution with 27ml water for each plate to block.

3. Aß(1-42) monomer form, standard dilution:
Aß(1-42) Monomer Standard Stock: dissolve 0.5mg Aß(1-42) in 250µl 0.1%NH_4OH; conc.: 2mg/ml; freshly prepared; use immediately.
Add 5µl Aß(1-42)-monomer standard stock solution to 995µl PBST = 10µg/ml.
Add 5µl, 10µg/ml Aß(1-42)-monomer standard solution to 4995µl PBST = 10ng/ml.

Standard curve:

No Final conc.	Stock	PBST
1 10000pg/ml	2ml B	0ml
2 3160pg/ml	0.633ml (1)	1.367ml
3 1000pg/ml	0.633ml (2)	1.367ml
4 316pg/ml	0.633ml (3)	1.367ml
5 100pg/ml	0.633ml (4)	1.367ml
6 31.6pg/ml	0.633ml (5)	1.367ml
7 10pg/ml	0.633ml (6)	1.367ml
8 0.0pg/ml	0ml	2ml

Samples:

IP : immunoprecipitate samples

No dilution factor	sample	PBST
1 directly	0.4ml IP	0ml
2 1:5	0.1ml (1)	0.4ml
3 1:25	0.1ml (2)	0.4ml
4 1:125	0.1ml (3)	0.4ml

Procedure Used:

1. Primary antibody:
   Dilute the concentrated anti-Aß (1-42) pAb in PBST buffer. The dilution factor is 1/1250 = 0.2µg/ml. Use immediately.

2. Label Reagent:
   Reconstitute anti-rabbit-POD conjugate lyophilizate in 0.5ml water. Add 500µl glycerol and store aliquots of 100µl at -20°C for further use.
   Dilute the concentrated Label reagent in PBST-buffer. The dilution factor is 1/5000. Use immediately.

3. TMB solution:
   Mix 20ml 100mM sodium acetate pH4.9 with 200µl of the TMB solution and 29.5µl 3% Peroxide solution. Use immediately.

Sample Plate Setup: (Note that all standards and samples are run in duplicate.)

	1	2	3	4	5	6	7	8	9	10	11	12
A	10000	10000	U1	U1								
B	3160	3160	U2	U2								
C	1000	1000	U3	U3								
D	316	316	U4	U4								
E	100	100	U5	U5								
F	31.6	31.6	U6	U6								
G	10	10	U7	U7								
H	0.0	0.0	U8	U8								

U1-U# = Unknown samples

Procedure Used:

1. Apply 100μl binding antibody solution per well and incubate overnight at 4°C.
2. Discard the antibody solution and wash the wells with 250μl PBST-buffer for three times.
3. Add 260μl block solution per well and incubate 2h at room temperature.
4. Discard the block solution and wash the wells with 250μl PBST-buffer for three times.
5. After preparation of standards and samples, apply 100μl per well of standards and samples to the plate. Incubate 2h at room temperature and overnight at 4°C.
6. Discard the standard/sample solution and wash the wells with 250μl PBST-buffer for three times.
7. Add 200μl primary antibody solution per well and incubate 1.5h at room temperature.
8. Discard the antibody solution and wash the wells with 250μl PBST-buffer for three times.
9. Add 200μl label solution per well and incubate 1h at room temperature.
10. Discard the label solution and wash the wells with 250μl PBST-buffer for three times.
11. Add 100μl of TMB solution to each well and incubate at room temperature (5-15min).
12. Observe color staining and apply 50μl of the Stop Solution per well.
13. Read at 450nm.
14. Calculate results from standard curve.
15. Evaluation:

If extinction from unknown samples is not in the linearity range of the calibration curve, repeat ELISA with appropriate sample dilution.

RESULTS:

	Aß40 ELISA (Signet)		Aß42 ELISA (Signet)		Aß42/40
MCI samples (n=4)	Aß(1-40)	SEM	Aß(1-42)	SEM	
without IP	11678,9	2879,4	1242,0	353,5	7,84%
6E10 IP	8282,4	2185,7	2035,1	280,9	17,35%
8F5 IP	8586,1	2396,6	2654,6	411,4	20,95%
AD samples (n=2)	Aß(1-40)	SEM	Aß(1-42)	SEM	
without IP	7297,5	1464,5	843,0	157,5	10,95%
6E10 IP	5610,2	28,3	1453,0	14,5	20,57%
8F5 IP	4133,9	86,9	1670,2	12,3	28,78%

The above results indicate the following:

a. A globulomer preferential antibody like 8F5 (or 8C5), in comparison to a non-globulomer selective antibody like 6E10, binds preferentially to Aβ42 compared to Aβ40 independent from the disease state. This result is indicative of a successful treatment for Alzheimer's Disease because preferentially eliminating Aβ42 over Aβ40 is being followed as a concept in AD-treatment, e.g., by the use of R-flubiprofen, Flurizan which has demonstrated efficacy in AD treatment in a clinical trial published by Myriad Inc. This concept was published by S. Weggen et al. (J Biol Chem. (2003) 278(34):31831-7). The results are shown in Figure 3.

b. A globulomer preferential antibody like 8F5 (or 8C5) binds to even more Aβ42 than Aβ40 in patients compared to healthy controls. This result is even more indicative of a successful treatment for Alzheimer's Disease because, as noted above, preferentially eliminating Aβ42 over Aβ40 is being followed as a concept in AD-treatment (e.g., by the use of

non-steroidal anti-inflammatory drugs, like R-flubiprofen). (See Figure 3.)

B) ENDOGENOUS AMYLOID ß(1-42) AND AMYLOID ß(1-40) LEVELS IN HUMAN CSF AFTER IMMUNOPRECIPITATION WITH GLOBULOMER SELECTIVE ANTI-Aß MURINE MAB 8F5 OR 8C5 IN COMPARISON WITH GLOBULOMER UNSELECTIVE ANTIBODY 6E10:

b1) Immunoprecipitation (IP) with Dynabeads M-280 Sheep anti-Mouse IgG

Abeta-antibody solutions

The following pure antibodies were obtained from hybridomas according to standard purification procedures:

- mMab 6E10; Fa.Signet Nr.: 9320; 1mg/ml in PBS buffer
- mMab 8F5; 1.65mg/ml in PBS buffer
- mMab 8C5; 1.44mg/ml in PBS buffer

Dynabeads M-280 Sheep anti-Mouse IgG:

Sheep anti-Mouse IgG (Invitrogen Inc., Cat. no.: 112.02) is covalently bound to magnetic beads (Dynabeads).

Activation of Dynabeads with monoclonal mouse antibodies

- The stock-suspension of dynabeads (Dynabeads M-280 Sheep anti-Mouse IgG, Invitrogen; Prod. No. 112.02) was shaken carefully to prevent foaming.
- 1 mL was aseptically removed and transferred to a 1.5 mL reaction vial.
- The dynabeads were washed 3 times 5 min with 1 mL immunoprecipitation (IP)-wash buffer (IP-wash-buffer: PBS

(20 mM NaH_2PO_4, 140 mM NaCl, pH 7.4), 0.1% (w/v) BSA). During the washing procedure, the supernatant was carefully removed while the dynabeads were immobilized at the side of the reaction vial with a magnetic separator stand (MSS).

- The washed dynabeads were incubated with 40 µg Abeta-antibody in 1 mL PBS, 0.1% (w/v) BSA.
- The activation was carried out by overnight incubation under shaking at 4°C.
- The activated dynabeads were washed 4 times 30 min (again using the MSS) with 1 mL IP-wash buffer (PBS (20 mM NaH_2PO_4, 140 mM NaCl, pH 7.4), 0.1% (w/v) BSA).
- The activated dynabeads were resuspended with 1 mL PBS, 0.1% (w/v) BSA, 0.02 (w/v) % Na-Azide; vortexed and centrifuged briefly.
- The antibody activated dynabeads were stored at 4°C until further use.

CSF Sample preparation:

400 µL CSF from an Alzheimer's disease patient were added to 4 µL Complete Protease Inhibitor Cocktail (Roche Inc. Cat. no.: 1697498, 1 tablet dissolved in 1 mL water) and 0.8 µL 500 mM PMSF dissolved in methanol. After 10 min., 1.6 mL 20 mM NaH_2PO_4,140 mM NaCl, 0.05% Tween 20, pH 7.4 (PBST) was added.

Immunoprecipitation of Abeta species from human AD-CSF:

250 µL aliquot of the prepared CSF sample were added to 25 µL anti-Aß-Dynabeads suspension.

- Immunoprecipitation occurred under stirring at 6°C for 16 hours. Subsequent washing of the beads was performed 3 times 5 min. with 1 mL PBS/0,1% (w/v) BSA and finally once 3 min. with 1 mL 10 mM Tris/HCL pH 7.5 buffer. During the washing procedure, the supernatant was carefully removed while the dynabeads were immobilized at the side of the reaction vial with a magnetic separator stand (MSS).

The residual supernatant was thoroughly removed after the final washing step. The Abeta peptides and the corresponding antibody were removed from the Dynabeads by adding 25 µL sample buffer without β-Mercaptoethanol (0.36 M Bistris, 0.16 M Bicine, 1% SDS (w/v), 15% (w/v) sucrose, 0.004% (w/v) Bromphenolblue) to the Eppendorff tube and heating for 5 min at 95°C in a heating block. After cooling to room temperature, the dynabeads were immobilized at the side of the reaction vial with a magnetic separator stand (MSS), and the supernatant was transferred to another Eppendorff tube (IP eluate).

Analysis of Abeta immunoprecipitates by urea-PAGE followed by Western Blot procedure:

The quantification of Aß1-40 and Aß1-42 species was performed by a 8 M Urea Poly-Acrylamide-Gel-Electrophoresis system and subsequent Western Blot analysis according to the procedure first described by H.W. Klafki et al., Analytical Biochemistry 237, 24-29 (1996) and later also used by J. Wiltfang et al., J. of Neurochemistry 81, 481-496, 2002. There were only two minor changes made in the experimental procedure:

1) SDS concentration in the stacking gel was adjusted to 0.25% (w/v) instead of 0.1% (w/v).
2) For the Western blot the antibody 1E8 (Senetek Drug Delivery Technologies Inc. St.Louis, MO, USA) was replaced by Anti-Human Amyloid β (N) (82E1) Mouse IgG mAb (IBL, Cat.no.: 10323)

15 μL IP eluate aliquots of the immunoprecipitated samples were loaded onto the 8 M Urea PAGE. Electrophoresis was performed at 100 V (15 min) and continued at 60 V. The electrophoresis was stopped when the running front of the blue sample loading dye was still 0.5 cm away from the end of the gel.

Western blot procedure:

Western blot analysis was performed in a Semi Dry Blotting chamber (BioRad Inc., 45min at 75mA) onto 7.5cm x 9cm Nitrocellulose 0.45μm (BioRad Inc.).

Blotting buffer: 6 g Tris; 28.1 g Glycin; 500m L Methanol; adjust to 2.5 l with water.

The Nitrocellulose blot was boiled for 10 min in PBS at 100°C. The blot was saturated by treatment with 50 mL 5 % (w/v) BSA in PBST for 1 hour at RT. After removal of the fluid phase, the following washing step was performed twice with: 50 mL TTBS (25 mM Tris / HCl; 150 mM NaCl Puffer; 0.05% Tween 20; pH 7.5) for 10 min at RT and subsequently with 50 mL TBS (25 mM Tris / HCl; 150 mM NaCl buffer; pH 7.5) for 10 min at RT.

For further development, the final washing buffer was discarded from the blot and 15 mL antibody I solution (0.2 µg/mL 82E1 = 1:500 in 3 % (w/v) skimmed milk powder (Lasana Inc.), in 15 mL TBS) were added for 20 hours at 6°C. Removal of buffer was followed by the three wash steps as described above. The blot was incubated with Antibody solution II (1:10000 dilution of anti-Mouse -POD in 15 mL 3 % (w/v) skimmed milk powder in 15 mL TBS) for 1 hour at RT. Removal of buffer was followed by the three wash steps as described above.

After removal of the last washing buffer, 2 mL Super Signal West Femto Maximum Sensitivity Substrate Enhancer and 2 mL Peroxide Solution was mixed. The freshly prepared solution was poured onto the blot which was preincubated in the dark for 5 min. Chemiluminescence was recorded using a VersaDoc Imaging system(BioRad).

Imaging parameters:
- exposure time 180 sec.
Picture records after 30 sec., 60sec., 120 sec. and 180 sec.

The results were obtained from the picture with 180 sec. exposure time.

	Aß40 urea-PAGE [pg/ml]	Aß42 urea-PAGE [pg/ml]	Ratio Aß42/Aß40+42 x100%
6E10 IP	4389	202	4.4%
8F5 IP	1260	112	8.1%
8C5 IP	1202	211	14.9%

The above results indicate that a globulomer preferential antibody like 8F5 or 8C5, in comparison to a non-globulomer selective antibody like 6E10, binds to more Aβ42 than Aβ40 in human CSF. This result is indicative of a successful treatment for Alzheimer's Disease because, as noted above, preferentially eliminating Aβ42 over Aβ40 is being following as a concept in AD-treatment (e.g., by the use of R-flubiprofen (see above)).

EXAMPLE V

8F5 IMPROVES NOVEL OBJECT RECOGNITION IN APP TRANSGENIC MICE

In order to test a positive effect on cognition by neutralizing internal Aß(1-42) globulomer epitope with antibody 8F5, a passive immunization experiment with APP transgenic mice was performed in which the mice were tested for their ability to remember objects they have investigated before. After some time, delay between first and second encounter of objects, APP transgenic mice are not able to recognize the already investigated object. This experiment is based on the natural curiosity of the animals, and a significant lack of interest in the already investigated object demonstrates recognition of the object.

EXAMPLE V.1: INCREASED RECOGNITION INDEX BY MONOCLONAL ANTIBODY 8F5:

Animals:

Female mice of a single transgenic mouse model of Alzheimer's Disease in FVB x C57Bl background (APP/L, ReMYND, Leuven, Belgium) and negative litter mates as wild type controls in FVB x C57Bl background with an age of 3 months were used. All

mice were genotyped by polymerase chain reaction (PCR) at the age of 3 weeks and received a unique identity number, once the PCR results were known and were double checked by a second PCR before the onset of the study. All mice were randomized and age-matched, i.e., they were given a random number by computer and allocated randomly to a treatment. Animals were caged by treatment group 18 days before the onset of the study in order to allow them to familiarize to the new cage context. Mice had free access to pre-filtered and sterile water (UV-lamp) and standard mouse chow. The food was stored under dry and cool conditions in a well-ventilated storage room. The amount of water and food was checked daily, supplied when necessary and refreshed twice a week. Mice were housed under a reversed day-night rhythm: 14 hours light/10 hours darkness starting at 7 p.m. in standard metal cages type RVS T2 (area of 540 cm2). The cages are equipped with solid floors and a layer of bedding litter. The number of mice per cage was limited in accordance with legislation on animal welfare. Five days before the onset of the behavior test, mice were replaced in macrolon Type 2 cages and transported to the laboratory in order to adapt to the laboratory environment in preparation for the behavior test.

Treatment (Passive Immunization):

Three individual experiments were performed in which the mice (at least 9 per group) received intraperitoneal injections (500 μg in 240μL / mouse) at days 1, 8 and 15. Mice were treated with monoclonal antibodies 6G1, 8F5 and other non-disclosed antibodies, all dissolved in phosphate-buffered saline, or with 320 μL phosphate-buffered saline.

Novel object recognition test:

The novel object recognition test was performed on the day of the third treatment. The protocol used followed the method as described by Dewachter *et al.* (Journal of Neuroscience, 2002, 22(9):3445-3453). Mice were familiarized for one hour to a Plexiglas open-field box (52 x 52 x 40 cm) with black vertical walls and a translucent floor, dimly illuminated by a lamp placed underneath the box. The next day, the animals were placed in the same box and submitted to a 10 minute acquisition trial. During this trial, mice were placed individually in the open field in the presence of 2 identical objects A (orange barrel or green cube, similar size of ± 4 cm), and the duration ($time_{AA}$) and the frequency ($Freq_{AA}$) exploring object A (when the animals snout was directed towards the object at a distance of < 1 cm and the mice were actively sniffing in the direction of the object) was recorded by a computerized system (Ethovision, Noldus information Technology, Wageningen, Netherlands). During a 10 minute retention trial (second trial) performed 2.5 hours later, a novel object (object B, green cube or orange barrel) was placed together with the familiar object (object A) into the open field ($Freq_A$ and $Freq_B$ and $Time_A$ and $Time_B$, respectively). The recognition index (RI), defined as the ratio of the duration in which the novel object was explored over the duration in which both objects were explored [$Time_B$ / ($Time_A$ + $Time_B$) x 100], was used to measure non-spatial memory. The duration and frequency that object A was explored during the acquisition trial ($Time_{AA}$ and $Freq_{AA}$) was used to measure curiosity.

Analysis of data was done by combining APP transgenic mice that received monoclonal antibodies 6G1 or 8F5 or phosphate-buffered saline, and non-transgenic littermates that received phosphate-buffered saline, from all three studies (Fig. 4).

Mice that do not distinguish between an old object and a novel object have a recognition index of 50. Mice that recognize the old object will preferably explore the novel object and hence the recognition index becomes > 50. Mice that exclusively explore the novel object have a recognition index of 100. The mean recognition index per group was compared against chance level, i.e., 50, by t-test. The mean recognition index of all groups was also compared by ANOVA followed by a post-hoc t-test. The difference between PBS and wild type groups indicated a cognitive deficit of APP transgenic mice in this paradigm. PBS-injected mice performed at chance level (i.e., not significantly different from 50) while all other mice showed object recognition (Fig. 4: stars). When the performance of antibody-treated APP transgenic mice was compared with control groups, a significant difference was found versus PBS-treated but not versus wild-type mice (Fig. 4: circles) indicating that treatment with antibody 8F5 reversed the cognitive deficit in these APP transgenic mice.

EXAMPLE VI

IN SITU ANALYSIS OF THE SPECIFIC REACTION OF ANTIBODIES 8F5 AND 8C5 TO FIBRILLAR AMYLOID BETA PEPTIDE IN THE FORM OF AMYLOID PLAQUES AND AMYLOID IN MENINGEAL VESSELS IN OLD APP TRANSGENIC MICE AND ALZHEIMER'S DISEASE PATIENTS

Antibodies 8F5 and 8C5 show reduced staining to fibrillar Aβ peptide deposits suggesting that their therapeutic effect is mediated by binding to soluble globulomeric forms rather than fibrillar deposited forms of Aβ peptide. Since antibody binding to fibrillar Aβ peptide can lead to fast dissolution of aggregates and a subsequent increase of soluble Aβ concentration, which in turn is thought to be neurotoxic and

could lead to microhemorrhages, an antibody therapy that effects the soluble globulomer rather than the monomer is preferred.

Methods:

For these experiments, several brain material samples were used: cortical tissue from 2 AD patients (RZ16 and RZ 55)and cortical tissue from 19 month old Tg2576 mice (APPSWE # 001349,Taconic, Hudson, NY, USA) or 12 month old APP/L mice (ReMYND, Leuven, Belgium).
The mice overexpress human APP with a familial Alzheimer's disease mutation and form β-amyloid deposits in the brain parenchyma at about 11 months of age and β-amyloid deposits in larger cerebral vessels at about 18 months of age. The animals were deeply anaesthetized and transcardially perfused with 0.1 M phosphate-buffered saline (PBS) to flush the blood. Then, the brain was removed from the cranium and divided longitudinally. One hemisphere of the brain was shock-frozen and the other fixated by immersion into 4% paraformaldehyde. The immersion-fixated hemisphere was cryoprotected by soaking in 30% sucrose in PBS and mounted on a freezing microtome. The entire forebrain was cut into 40 μm transverse sections which were collected in PBS and used for the subsequent staining procedure. The neocortex samples from Alzheimer's disease patients were obtained from Brain-Net, Munich, Germany as frozen tissue, immersion-fixated in 4% paraformaldehyde during thawing, and subsequently treated like the mouse tissue.

Individual sections were stained with Congo Red using the following protocol:

Material:

- Amyloid dye Congo Red kit (Sigma-Aldrich; HT-60), consisting of alcoholic NaCl solution, NaOH solution and Congo Red solution
- staining cuvettes
- microscope slides SuperfrostPlus and coverslips
- Ethanol, Xylol, embedding medium

Reagents:

- NaOH diluted 1:100 with NaCl solution yields alkaline saline
- alkaline saline diluted 1:100 with Congo Red solution yields alkaline Congo Red solution (prepare no more than 15 min before use, filtrate)
- mount sections on slide and allow them to dry
- incubate slide in staining cuvette, first for 30-40 minutes in alkaline saline, then for 30-40 minutes in alkaline Congo Red solution
- rinse three times with fresh ethanol and embed over xylol

Staining was first photographed using a Zeiss Axioplan microscope (Zeiss, Jena, Germany) and evaluated qualitatively. Red color indicated amyloid deposits both in the form of plaques and in larger meningeal vessels. Later on, evaluation of antibody staining focused on these structures.

Staining was performed by incubating the sections with a solution containing 0.07 - 0.7 μg/ml of the respective antibody in accordance with the following protocol:

Materials:

- TBST washing solution (Tris Buffered Saline with Tween 20; 10x concentrate; DakoCytomation S3306, DAKO, Hamburg, Germany) 1:10 in Aqua bidest.)
- 0.3% H_2O_2 in methanol
- donkey serum (Serotec, Düsseldorf, Germany), 5% in TBST, as blocking serum
- monoclonal mouse-anti-globulomer antibodies diluted at given concentrations in TBST
- secondary antibody: biotinylated donkey-anti-mouse antibody (Jackson Immuno / Dianova, Hamburg, Germany; 715-065-150; diluted 1:500 in TBST)
- StreptABComplex (DakoCytomation K 0377, DAKO, Hamburg, Germany)
- Peroxidase Substrate Kit diaminobenzidine (=DAB; SK-4100; Vector Laboratories, Burlingame, CA, USA)
- SuperFrost Plus microscope slides and coverslips
- xylol free embedding medium (Medite, Burgdorf, Germany; X-tra Kitt)

Procedure:

- transfer floating sections into ice-cold 0.3% H_2O_2 and incubate for 30 min
- wash for 5 min in TBST buffer
- incubate with donkey serum/TBST for 20 minutes
- incubate with primary antibody for 24 hours at room temperature
- wash in TBST buffer for 5 minutes
- incubate with blocking serum for 20 minutes
- wash in TBST buffer for 5 minutes
- incubate with secondary antibody for 60 minutes at ambient temperature
- wash in TBST buffer for 5 minutes

- incubate with StreptABComplex for 60 minutes at ambient temperature
- wash in TBST buffer for 5 minutes
- incubate with DAB for 20 minutes
- mount the section on slides, air-dry slides, dehydrate slides with alcohol and embed slides

Besides visual inspection of sections under the microscope, amyloid staining was additionally quantified by optically excising 10 randomly selected plaques from the histological images using the ImagePro 5.0 image analysis system and determining their average greyscale value. Optical density values (were calculated from the greyscale values by subtracting the mean background density of the stained material from the density of amyloid plaques (0% - no plaque staining above surrounding background, 100% - no transmission / maximal staining). The differences between between antibodies 6E10 / 4G8 and 6G1, 8C5 and 8F5, respectively, were tested for statistical significance with ANOVA.

Results:

All antibody-stained material described proved to be congophilic amyloid deposits (Fig. 7(A)). The globulomer-preferring antibodies 8F5 and 8C5 stained parenchymal and meningeal congophilic deposits of Aβ peptide significantly less than the antibodies 6G1 and 6E10 (Fig. 7(B)-(C),(H)). Quantitative analysis of parenchymal amyloid plaque staining revealed binding of all antibodies to plaques (statistically significant density above control), but binding of antibody 8F5 and 8C5 was significantly lower than binding of the reference antibody 6E10 (raised to N-terminal sequence of Aβ)

and equal or lower than reference antibody 4G8 (raised to N-terminal sequence of Aβ) (Fig. 7(D)-Fig. (G)). Antibodies 8F5 and 8C5 bind less to amyloid deposits than antibodies which recognize Aβ monomer or part of the Aβ sequence. Treatment with antibodies binding to fibrillar Aβ peptide can lead to fast dissolution of amyloid plaques in brain tissue and a subsequent increase of soluble Aβ concentration, which in turn is thought to be neurotoxic and could lead to microhemorrhages, and/or a fast dissolution of vascular amyloid, which also could lead to microhemorrhages. Therefore, an antibody therapy that affects the soluble globulomer rather than the monomer is preferred.

WHAT IS CLAIMED IS:

1. A humanized monoclonal antibody comprising a variable heavy and light chain, wherein:

the three CDRs of said variable heavy chain are SEQ ID NO:5, SEQ ID NO:6 and SEQ ID NO:7, and

the three CDRs of said variable light chain are SEQ ID NO:8, SEQ ID NO:9 and SEQ ID NO:10,

wherein the antibody binds with greater specificity to an amyloid beta protein globulomer than to an amyloid beta protein monomer.

2. The antibody of claim 1, wherein all or substantially all of the framework regions correspond to those of a human immunoglobulin consensus sequence.

3. The antibody of claim 1 or 2 for use in treating or preventing Alzheimer's Disease.

4. A pharmaceutical composition comprising an antibody of claim 1 or 2.

5. A vaccine comprising an antibody of claim 1 or 2 and a pharmaceutically acceptable adjuvant.

6. The use of an antibody of claim 1 or 2 in the manufacture of a medicament for treating or preventing Alzheimer's Disease.

7. A method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with an antibody of claim 1 or 2for a time and under conditions sufficient for formation of antigen/antibody complexes; and

(b) detecting presence of said antigen/antibody complexes in said sample, presence of said complexes indicating a diagnosis of Alzheimer's Disease in said patient.

8. A method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with an antigen that is an amyloid beta (Aβ) protein globulomer for a time and under conditions sufficient for the formation of antigen/antibody complexes;

(b) adding a conjugate to the resulting antibody/antigen complexes for a time and under conditions sufficient to allow said conjugate to bind to the bound antibody, wherein said conjugate comprises an antibody of claim 1 or 2; and

(c) detecting presence of said antigen/antibody complexes in said sample, presence of said complexes indicating a diagnosis of Alzheimer's Disease in said patient.

9. A method of diagnosing Alzheimer's Disease in a patient suspected of having this disease comprising the steps of:

(a) contacting a biological sample from said patient with anti-antibody, wherein said anti-antibody is specific for said antibody of claim 1 or 2 for a time and under conditions sufficient to allow for formation of anti-antibody/antibody complexes, said complexes containing antibody present in said biological sample;

(b) adding a conjugate to resulting anti-antibody/antibody complexes for a time and under conditions sufficient to allow said conjugate to bind to bound antibody, wherein said conjugate comprises an antigen, which binds to a signal generating compound capable of generating a detectable signal; and

(c) detecting a signal generated by said signal generating compound, said signal indicating a diagnosis of Alzheimer's Disease in said patient.

10. A method of identifying compounds suitable for active immunization of a patient predicted to develop Alzheimer's Disease comprising the steps of:

(a) exposing one or more compounds of interest to an antibody of claim 1 or 2 for a time and under conditions sufficient for said one or more compounds to bind to said antibody of claim 1 or 2; and

(b) identifying those compounds which bind to said antibody of claim 1 or 2, said identified compounds to be used in active immunization in a patient predicted to develop Alzheimer's Disease.

11. A kit comprising:

(a) an antibody of claim 1 or 2 and

(b) a conjugate comprising a second Aβ protein globulomer-specific antibody attached to a signal-generating compound capable of generating a detectable signal, wherein said second antibody of said conjugate is different from said antibody of claim 1 or 2.

12. A kit comprising:

(a) an anti-antibody to an antibody of claim 1 or 2 and

(b) a conjugate comprising an Aβ protein globulomer attached to a signal-generating compound capable of generating a detectable signal.