[Document Name] Description

[Title of Invention] ANTI-CD3 ANTIBODY AND MOLECULES COMPRISING THE ANTIBODY

[Technical Field]

[0001]

The present invention relates to a novel antibody which binds to human CD3 and binds to cynomolgus monkey CD3, and to molecules comprising the antibody.

[Background Art]

[0002]

1) Anti-CD3 monoclonal antibodies, as with any other monoclonal antibody, function by precise recognition of their target molecules. Each anti-CD3 antibody recognizes only a single epitope on the target CD3 molecule. Among monoclonal antibodies specific for a CD3 complex, OKT3 is most widely used and best characterized.

2) OKT3 is a mouse-derived anti-human CD3 monoclonal antibody (Non-Patent Document 1). Anti-CD3 monoclonal antibodies have been administered in a procedure to prevent transplanted organs from being rejected. The antibodies bind to TCR complexes on human T cells and suppress their activation and proliferation. This treatment has been used for a

long time in order to prevent the homograft rejection of an organ (Non-Patent Documents 2 through 4). OKT3 is the first anti-CD3 antibody to be used in such a procedure. OKT3 has a strong immunosuppressive effect, whereas its clinical use is hampered due to severe adverse reactions associated with its immunogenicity and mitogenic potential (Non-Patent Documents 5 to 8).

3) OKT3 induces T cell activation and cytokine production *in vitro* and releases large amounts of cytokines *in vivo* resulting in cytokine syndrome (Non-Patent Document 5). This is because OKT3 is a bivalent IgG molecule, and thus crosslinks T cells and Fcγ receptor-expressing cells, consequently causing T cell activation (Non-Patent Document 8). In addition, OKT3 is a mouse antibody and is therefore known to cause heterophilic antibodies such as Human Anti-Mouse Antibodies (HAMA) through long-term administration (Non-Patent Document 7). Reports on the application of anti-CD3 antibodies treatment and their adverse reactions are summarized below (Patent Document 1).

4) In order to solve these problems, scFv-formatted OKT3 (Non-Patent Document 9) and humanized OKT3 (Non-Patent Document 10) have been created. A bispecific antibody combining a single chain of OKT3 with a single chain of an antibody against a target antigen expressed on the surface of a cancer cell has

been reported in another example of an application of OKT3 (Patent Document 2 and Non-Patent Document 11).

5) Multispecific antibodies comprising the anti-CD3 antibodies described in the prior art are expected to have significant therapeutic potential in the treatment of malignant diseases. For example, TROP2 is known to be overexpressed in various types of epithelial tumors (Non-Patent Documents 12 to 16). An expressed bispecific antibody which genetically links a human TROP2-specific antibody to an antigen-binding fragment of an anti-CD3 antibody has not yet been reported.

6) OKT3 reacts with chimpanzee CD3, but does not react with CD3 derived from other primates such as cynomolgus monkeys (Non-Patent Document 17). Likewise, anti-CD3 monoclonal antibody UCHT-1 also reacts with chimpanzee-derived CD3, but does not react with cynomolgus monkey-derived CD3 (Non-Patent Document 18). On the other hand, some monoclonal antibodies have been found that recognize cynomolgus monkey antigens, but do not recognize their human counterparts. One example from this group is FN-18, which is a monoclonal antibody directed towards cynomolgus monkey-derived CD3 (Non-Patent Document 19).

7) The limitation of OKT3 and the series of modified OKT3 antibodies is their specificity to

human CD3. This limitation may constitute a considerable barrier to the development of therapeutic drugs for treating human diseases. This is because candidate drugs for development need to be subjected to preclinical trials to obtain marketing approval, and it is desirable to conduct such preclinical trials on animals, particularly higher primates such as cynomolgus monkeys. Thus, in the case of candidate drugs containing anti-CD3 antibodies, it is very desirable to use an anti-CD3 antibody able to bind both to human CD3 and to cynomolgus monkey CD3.

8) The cross-reactive antibody binding to both of human CD3 and cynomolgus monkey CD3 has been reported in Patent Documents 3 and 4 and Non-Patent Document 20. Also, a bispecific antibody in which a single chain of such an anti-CD3 antibody is bound with a single chain of an antibody against a target antigen expressed on cancer cell surface has been reported (Patent Document 5 and Non-Patent Document 21). However, in order to be able to apply multispecific antibodies or multispecific molecules to highly diverse applicable cancer targets, there is demand for an anti-CD3 antibody which binds to epitopes other than those mentioned above and binds to both human and cynomolgus monkey CD3.

[Prior Art]

[0003]

[Patent Documents]

[Patent Document 1] International Publication No. WO2012/162067

[Patent Document 2] International Publication No. WO2007/108152A1

[Patent Document 3] U.S. Patent Publication No. 8236308B2

[Patent Document 4] International Publication No. WO2008/119567A1

[Patent Document 5] International Publication No. WO2015/026892A1

[0004]

[Non-Patent Document]

[Non-Patent Document 1] Salmeron A. et al., J. Immunol. (1991) 147, 3047-3052

[Non-Patent Document 2] Cosmi AB. et al., Transplantation (1981) 32, 535-539

[Non-Patent Document 3] Gilbert EM. et al., Am.J.Med. (1987) 82, 202-206

[Non-Patent Document 4] Thistlethwaite JR. et al., Transplanation (1987) 43, 176-184

[Non-Patent Document 5] Abramowicz D. et al., Transplanation (1989) 47, 606-608

[Non-Patent Document 6] Toussaint D. et al., Transplanation (1989) 48, 524-526

[Non-Patent Document 7] Thistlethwaite, JR. et al., Am. J. Kidney Dis. (1988) 11, 112-119

[Non-Patent Document 8] Meuer, SC. et al., Eur. J. Immunol. (1986) 136, 4106-4112

[Non-Patent Document 9] George AJ. et al., J. Immunol. (1994) 152 (4), 1802-11

[Non-Patent Document 10] Woodle ES. et al., J Immunol. (1992) 148 (9), 2756-63

[Non-Patent Document 11] Yankelevich M. et al., Pediatr. Blood Cancer (2012) 59 (7), 1198-1205

[Non-Patent Document 12] Ohmachi T. et al., Clin. Cancer Res. (2006) 12 (18), 3857-3863

[Non-Patent Document 13] Muhlmann G., et al., J. Clin. Pathol. (2009) 62 (2), 152-158

[Non-Patent Document 14] Fong D., et al., Br. J. Cancer (2000) 99 (8), 1290-1295.

[Non-Patent Document 15] Fong D. et al., Mod. Pathol. (2000) 21 (2) (2000), 186-191

[Non-Patent Document 16] Ning S., et al., Neurol. Sci. (2013) 34 (10), 1745-1750

[Non-Patent Document 17] Sandusky et al., J. Med. Primatol. (1986) 15, 441-451

[Non-Patent Document 18] http://www.nhpreagents.org/NHP/clonelist.aspx?ID=77

[Non-Patent Document 19] Uda et al., J.Med.Primatol. (2001) 30, 141-147

[Non-Patent Document 20] Conrad ML.et al., Cytometry A. (2007) 71 (11), 925-33

[Non-Patent Document 21] Lum LG. et al., BioDrugs (2011) 25 (6), 365-379.

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0005]

An object of the present invention is to provide a novel antibody or an antigen-binding fragment of the antibody (hereinafter, also referred to as an antibody, etc.) which binds to human CD3 and to cynomolgus monkey CD3, a molecule comprising the antibody, etc. and further comprising 1 or 2 or more additional antibodies or antigen-binding fragments of the antibodies, the molecule being multispecific, and a pharmaceutical composition having cytotoxic activity, etc. which includes the antibody, etc. or the molecule as an active ingredient.

[Means for Solving the Problem]

[0006]

The present inventors have conducted extensive research to achieve this object and have realized the present invention by developing a novel anti-CD3 antibody and a molecule comprising this antibody.

[0007]

Specifically, the present invention encompasses the following aspects:

(1) An antibody or an antigen-binding fragment of the antibody, characterized in that:

a heavy chain sequence comprises

CDRH1 comprising the amino acid sequence represented by SEQ ID NO: 26,
CDRH2 comprising the amino acid sequence represented by SEQ ID NO: 98, and
CDRH3 comprising the amino acid sequence represented by SEQ ID NO: 28;
a light chain sequence comprises
CDRL1 comprising the amino acid sequence represented by SEQ ID NO: 29,
CDRL2 comprising the amino acid sequence represented by SEQ ID NO: 99, and
CDRL3 comprising the amino acid sequence represented by SEQ ID NO: 31; and
the antibody or antigen-binding fragment binds to human CD3 and to cynomolgus monkey CD3.
(2) An antibody or antigen-binding fragment of an antibody according to (1), wherein
in CDRH2
the first Xaa is selected from a group consisting of A, E, G, H, I, L, T, V, R, and S, and
the second Xaa is S, or
the first Xaa is N, and
the second Xaa is selected from a group consisting of E, R, F, Y, L, V, I, K, and T,
in CDRL2,
Xaa is selected from a group consisting of Q, A, G, S, N, and D, and
the antibody or antigen-binding fragment binds to

human CD3 and to cynomolgus monkey CD3.

(3) An antibody or antigen-binding fragment of an antibody according to (1) or (2), wherein

in CDRH2,

the first Xaa is selected from a group consisting of R and S, and the second Xaa is S,

in CDRL2,

Xaa is selected from a group consisting of Q, A, G, S, N, and D, and

the antibody or antigen-binding fragment binds to human CD3 and to cynomolgus monkey CD3.

(4) An antibody or antigen-binding fragment of an antibody according to (1), wherein

the heavy chain sequence comprises a variable region having CDRH1, CDRH2, and CDRH3,

CDRH1 consisting of an amino acid sequence represented by SEQ ID NO: 26,

CDRH2 consisting of an amino acid sequence represented by SEQ ID NO: 27, and

CDRH3 consisting of an amino acid sequence represented by SEQ ID NO: 28;

the light chain sequence comprises a variable region having CDRL1, CDRL2, and CDRL3,

CDRL1 consisting of an amino acid sequence represented by SEQ ID NO: 29,

CDRL2 consisting of an amino acid sequence represented by SEQ ID NO: 30, and

CDRL3 consisting of an amino acid sequence

represented by SEQ ID NO: 31; and
the antibody or antigen-binding fragment binds to human CD3 and to cynomolgus monkey CD3.
(5) An antibody or antigen-binding fragment of an antibody according to any one of (1) to (4), wherein the heavy chain variable region sequence comprises an amino acid sequence represented by SEQ ID NO: 100.
(6) An antibody or antigen-binding fragment thereof according to (5), wherein
in the amino acid sequence represented by SEQ ID NO: 100,
the first Xaa is selected from a group consisting of A, E, G, H, I, L, T, V, R, and S, and
the second Xaa is S, or
the first Xaa is N, and
the second Xaa is selected from a group consisting of E, R, F, Y, L, V, I, K, and T.
(7) An antibody or antigen-binding fragment thereof according to (5), wherein
in the amino acid sequence represented by SEQ ID NO: 100,
the first Xaa is selected from a group consisting of R and S, and the second Xaa is S.
(8) An antibody or antigen-binding fragment thereof according to any one of (1) to (7), wherein the light chain variable region comprises an amino acid sequence represented by any one of SEQ ID NOs: 101, 102, and 103.

(9) An antibody or antigen-binding fragment thereof according to (8), wherein
in the amino acid sequence represented by any one of SEQ ID NOs: 101, 102, and 103,
Xaa is selected from a group consisting of Q, A, G, S, N, and D.
(10) An antibody or antigen-binding fragment of an antibody according to (5), wherein the heavy chain variable region sequence comprises an amino acid sequence represented by SEQ ID NO: 16.
(11) An antibody or antigen-binding fragment of an antibody according to (8), wherein the light chain variable region sequence comprises an amino acid sequence represented by any one of SEQ ID NOs: 17, 20, and 23.
(12) An antibody or binding fragment thereof according to (1) or (2), wherein the antibody or antibody binding fragment comprises a heavy chain variable region comprising an amino acid sequence represented by SEQ ID NO: 100 and a light chain variable region comprising an amino acid sequence represented by any one of SEQ ID NOs: 101, 102, and 103, wherein

in the amino acid sequence represented by SEQ ID NO: 100,
the first Xaa is selected from a group consisting of A, E, G, H, I, L, T, V, R, and S, and the second Xaa is S, or

the first Xaa is N, and the second Xaa is selected from a group consisting of E, R, F, Y, L, V, I, K, and T, and

in the amino acid sequence represented by any one of SEQ ID NOs: 101, 102, and 103,

Xaa is selected from a group consisting of Q, A, G, S, N, and D.

(13) An antibody or binding fragment thereof according to (12), wherein

in SEQ ID NO: 100

the first Xaa is selected from a group consisting of R and S, and

the second Xaa is S, and

in the amino acid sequence represented by any one of SEQ ID NOs: 101, 102, and 103,

Xaa is selected from a group consisting of Q, A, G, S, N, and D.

(14) An antibody or antigen-binding fragment of an antibody according to (13) comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 60 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 60,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 64 and a light chain variable region comprising the 135th through 241st amino acid

residues of SEQ ID NO: 64,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 66 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 66,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 68 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 68,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 70 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 70,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 72 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 72,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues

of SEQ ID NO: 74 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 74,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 76 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 76,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 78 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 78,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 80 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 80,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 82 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 82, or

an antibody or antigen-binding fragment of the

antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 84 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 84.

(15) An antibody or antigen-binding fragment of an antibody according to (1), (4), (5), (8), (10), or (11), wherein the antibody or antigen-binding fragment comprises a heavy chain variable region comprising an amino acid sequence represented by SEQ ID NO: 16, a linker, and a light chain variable region comprising an amino acid sequence represented by any one of SEQ ID NOs: 17, 20, and 23.

(16) An antibody or antigen-binding fragment of an antibody according to any one of (1) to (15), wherein a heavy chain variable region binds to a light chain variable region in this order, or a light chain variable region binds to a heavy chain variable region in this order, from the amino-terminal, and optionally:i)has a linker between both variable regions, ii)has a glycine residue at amino-terminal of a variable region on the amino-terrminal side, and iii)has a linker, FLAG tag and/or HIS tag at carboxyl terminal of a variable region on the carboxyl terminal side.

(17) An antibody or antigen-binding fragment of an antibody according to (16) including

an amino acid sequence comprising the 2nd through

243rd amino acid residues of SEQ ID NO: 60,
an amino acid sequence comprising the 2nd through 241st amino acid residues of SEQ ID NO: 64,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 66,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 68,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 70,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 72,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 74,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 76,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 78,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 80,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 82, or
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 84.

(18) An antibody or antigen-binding fragment of an antibody according to (16) including
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 19,
an amino acid sequence comprising the 2nd through

269th amino acid residues of SEQ ID NO: 22,
an amino acid sequence comprising the 2nd through 267th amino acid residues of SEQ ID NO: 25,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 60,
an amino acid sequence comprising the 2nd through 267th amino acid residues of SEQ ID NO: 64,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 66,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 68,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 70,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 72,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 74,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 76,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 78,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 80,
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 82, or
an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 84.

[0008]

(19) An antibody or an antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment comprises an amino acid sequence encoded by a nucleotide sequence contained in a polynucleotide which hybridizes under stringent conditions with a complementary strand of a polynucleotide including a nucleotide sequence encoding an amino acid sequence contained in an antibody or an antigen-binding fragment of the antibody according to any one of (14) to (18), and binds to human CD3 and to cynomolgus monkey CD3.

(20) An antibody or an antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment comprises a heavy chain including an amino acid sequence at least 90% identical to the amino acid sequence of a heavy chain contained in an antibody or an antigen-binding fragment of the antibody according to any one of (14) to (18), and a light chain including an amino acid sequence at least 70% identical to the amino acid sequence of a light chain contained in the antibody or antigen-binding fragment of the antibody according to any one of (14) to (18), and binds to human CD3 and to cynomolgus monkey CD3.

(21) An antibody or an antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment comprises a heavy chain including an amino acid sequence derived by the substitution, deletion,

or addition of 1 or more amino acid(s) from an amino acid sequence contained in a heavy chain contained in an antibody or an antigen-binding fragment of the antibody according to any one of (14) to (18), and a light chain including an amino acid sequence derived by the substitution, deletion, or addition of 1 or more amino acids from an amino acid sequence contained in a light chain contained in the antibody or antigen-binding fragment of the antibody according to any one of (14) to (18), and binds to human CD3 and to cynomolgus monkey CD3.

(22) An antibody or an antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment binds to the same site on human CD3 as that bound by an antibody or an antigen-binding fragment of the antibody according to any one of (14) to (18), and binds to cynomolgus monkey CD3.

(23) An antibody or an antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment competes with an antibody or an antigen-binding fragment of the antibody according to any one of (14) to (18) to bind to human CD3, and binds to cynomolgus monkey CD3.

(24) An antibody or antigen-binding fragment of the antibody according to (22), wherein the site on human CD3 bound by the antibody is constituted by 7 or more amino acids selected from the 55th serine (Ser), the 56th glutamic acid (Glu), the 58th leucine (Leu), the

59th tryptophan (Trp), the 65th asparagine (Asn), the 66th isoleucine (Ile), the 77th serine (Ser), the 78th aspartic acid (Asp), the 101st arginine (Arg), the 102nd glycine (Gly), the 103rd serine (Ser), the 104th lysine (Lys), and the 105th proline (Pro) in the amino acid sequence represented by SEQ ID NO: 1.

(25) An antibody or antigen-binding fragment of the antibody according to any one of (1) to(17) and (19) to (24), wherein the antibody is IgG.

(26) An antibody or antigen-binding fragment of an antibody according to any one of (1) to (24), wherein the antigen-binding fragment is selected from a group consisting of Fab, F(ab)', Fv, scFv, and sdAb.

(27) An antibody or antigen-binding fragment of an antibody according to any one of (1) to (17) and (19) to (25), wherein the antibody is a humanized antibody or a human antibody including a human immunoglobulin constant region.

(28) A polynucleotide comprising a nucleotide sequence encoding the amino acid sequence of an antibody or an antigen-binding fragment of the antibody according to any one of (1) to (27).

(29) A polynucleotide according to (28), wherein the polynucleotide comprises a nucleotide sequence encoding an amino acid sequence represented by

an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 19,

an amino acid sequence comprising the 2nd through

243rd amino acid residues of SEQ ID NO: 22,
an amino acid sequence comprising the 2nd through 241st amino acid residues of SEQ ID NO: 25,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 60,
an amino acid sequence comprising the 2nd through 241st amino acid residues of SEQ ID NO: 64,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 66,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 68,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 70,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 72,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 74,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 76,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 78,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 80,
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 82,
or
an amino acid sequence comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 84.

(30) A vector comprising a polynucleotide according to (28) or (29).

(31) A cell comprising a polynucleotide according to (28) or (29) or a vector according to (30), or producing an antibody or an antigen-binding fragment of the antibody according to any one of (1) to (27).

(32) A method for producing an antibody or an antigen-binding fragment of the antibody which binds to human CD3 and to cynomolgus monkey CD3, the method comprising the steps of: culturing a cell according to (31); and recovering an antibody or an antigen-binding fragment of the antibody which binds to human CD3 from the cultures.

(33) An antibody or an antigen-binding fragment of the antibody which binds to human CD3 and cynomolgus monkey CD3, the antibody or antigen-binding fragment being obtained by a method according to (32).

(34) A pharmaceutical composition comprising an antibody or an antigen-binding fragment of the antibody according to any one of (1) to (27) and (33) as an active ingredient.

(35) A molecule having antigen binding activity, comprising an antibody or an antigen-binding fragment of the antibody according to any one of (1) to (27) and (33).

(36) A molecule according to (35), wherein the molecule is multispecific.

[0009]

(37) A molecule according to (35) or (36), further comprising 1 or 2 or more additional antibodies or antigen-binding fragments of the antibodies in addition to the antibody or antigen-binding fragment of the antibody according to any one of (1) to (27) and (33).

(38) A molecule according to (37), wherein the antigen-binding fragment of the additional antibody is Fab, F(ab)', Fv, scFv, or sdAb.

(39) A molecule according to (38), wherein the molecule comprises Fc.

(40) A molecule according to any one of (37) to (38), wherein the additional antibody is a humanized antibody or a human antibody comprising a human immunoglobulin constant region.

(41) A molecule according to any one of (37) to (38), wherein the additional antibody or antigen-binding fragment of the antibody is bound with the antibody or antigen-binding fragment of the antibody according to any one of (1) to (27) and (33) via a linker or without a linker.

(42) A molecule according to (41), wherein a carboxyl terminus of the amino acid sequence of the additional antibody or antigen-binding fragment of the antibody is bound with a linker, and a carboxyl terminus of the amino acid sequence of the linker is further bound with the antibody or antigen-binding fragment of the antibody according to any one of (1) to (27)

and (33).

(43) A molecule according to (42), wherein the molecule comprises an amino acid sequence in which a carboxyl terminus of the amino acid sequence of the additional antibody or antigen-binding fragment of the antibody is bound with a linker, and a carboxyl terminus of the amino acid sequence of the linker is further bound with

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 19,

the antibody or antigen-binding fragment of the antibody comprising of the 2nd through 243rd amino acid residues of SEQ ID NO: 22, or

the antibody or antigen-binding fragment of the antibody comprising of the 2nd through 241st amino acid residues of SEQ ID NO: 25.

(44) A molecule according to any one of (35) to (42), comprising the antibody or antigen-binding fragment of the antibody according to any one of (1) to (27) and (33), wherein the variable region comprises a heavy chain variable region and a light chain variable region in this order, or a light chain variable region and a heavy chain variable region in this order, from the amino-terminal, and optionally:i)has a linker between both variable regions, ii)has a glycine residue at amino-terminal of variable region on the amino-terminal side, and

iii)has a linker, FLAG tag and/or HIS tag at carboxyl terminal of a variable region on the carxoyl terminal side. Applicable forms include Hybrid type and Dual type bispecific molecules.

(45) A molecule according to (44), wherein the additional antibody or antigen-binding fragment of the antibody is bound with

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 19,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 241st amino acid residues of SEQ ID NO: 25,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 60,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 241st amino acid residues of SEQ ID NO: 64,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 66,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 68,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 70,

the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 72,
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 74,
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 76,
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 78,
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 80,
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 82, or
the antibody or antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 84. Applicable forms include Hybrid type and Dual type bispecific molecules.

(46) A molecule according to any one of (36) to (45), wherein the additional antibody is anti cancer target antibody.

(47) A molecule according to any one of (36) to (46), wherein the molecule is bispecific.

(48) A molecule according to any one of (35) to (47),

wherein the molecule is a polypeptide.

(49) A polynucleotide comprising a nucleotide sequence encoding the amino acid sequence of a molecule according to (48).

(50) A vector comprising a polynucleotide according to (49).

(51) A cell producing a polynucleotide according to (49) or a vector according to (50), or a molecule according to (48).

(52) A method for producing a molecule binding to human CD3 and to cynomolgus monkey CD3, the method comprising the steps of: culturing a cell according to (51); and recovering a molecule binding to human CD3 from the cultures.

(53) A molecule binding to human CD3 and cynomolgus monkey CD3, the molecule being obtained by a method according to (52).

(54) A pharmaceutical composition comprising a molecule according to any one of (35) to (48) and (53) as an active ingredient.

(55) A pharmaceutical composition according to (54), wherein the pharmaceutical composition induces cytotoxicity in target cells by the redirection of T cells to the target cells.

[Effect of Invention]

[0010]

The present invention is able to obtain a novel

anti-CD3 antibody or an antigen-binding fragment of the antibody which binds to human CD3 and binds to cynomolgus monkey CD3, and a novel molecule having antigen binding activity which includes the antibody, etc. In addition, a novel pharmaceutical composition is obtained which includes such an antibody, etc. or molecule as an active ingredient. The antibody, etc. or molecule has T cell dependent cytotoxic activity and is useful as a therapeutic or prophylactic agent for various diseases such as cancer.

[Brief Description of the Drawings]

[0011]

[Figure 1] Figure 1 is a diagram showing the amino acid sequence of human CD3ε.

[Figure 2] Figure 2 is a diagram showing the amino acid sequence of human CD3δ.

[Figure 3] Figure 3 is a diagram showing a nucleotide sequence encoding human CD3εγ single-chain antigen.

[Figure 4] Figure 4 is a diagram showing the amino acid sequence of human CD3εγ single-chain antigen.

[Figure 5] Figure 5 is a diagram showing the nucleotide sequence of a sense primer Nhe-polyC-S for heavy chain gene amplification.

[Figure 6] Figure 6 is a diagram showing the nucleotide sequence of a first antisense primer rIgγ-AS1 for heavy chain gene amplification.

[Figure 7] Figure 7 is a diagram showing the

nucleotide sequence of a second antisense primer rIgγ-AS2 for heavy chain gene amplification.

[Figure 8] Figure 8 is a diagram showing the nucleotide sequence of a sense primer Nhe-polyC-S2 for light chain gene amplification.

[Figure 9] Figure 9 is a diagram showing the nucleotide sequence of a first antisense primer rIgL-AS1 for light chain gene amplification.

[Figure 10] Figure 10 is a diagram showing the nucleotide sequence of a second antisense primer rIgL-AS2 for light chain gene amplification.

[Figure 11] Figure 11 is a diagram showing the nucleotide sequence of a sense primer rIgγ-seq for heavy chain sequencing.

[Figure 12] Figure 12 is a diagram showing the nucleotide sequence of an antisense primer 1 rIgL-seq1 for light chain sequencing.

[Figure 13] Figure 13 is a diagram showing the nucleotide sequence of an antisense primer 2 rIgL-seq2 for light chain sequencing.

[Figure 14] Figure 14 is a diagram showing a nucleotide sequence encoding the heavy chain variable region of C3-147.

[Figure 15] Figure 15 is a diagram showing the amino sequence of the heavy chain variable region of C3-147.

[Figure 16] Figure 16 is a diagram showing a nucleotide sequence encoding the light chain variable

region of C3-147.

[Figure 17] Figure 17 is a diagram showing the amino sequence of the light chain variable region of C3-147.

[Figure 18] Figure 18 is a diagram showing the oligonucleotide sequence of a G4S linker sense strand.

[Figure 19] Figure 19 is a diagram showing the oligonucleotide sequence of a G4S linker antisense strand.

[Figure 20] Figure 20 is a diagram showing a nucleotide sequence encoding C3E-7000.

[Figure 21] Figure 21 is a diagram showing the amino acid sequence in C3E-7000.

[Figure 22] Figure 22 is a diagram showing the amino acid sequence of the heavy chain variable region of C3E-7034.

[Figure 23] Figure 23 is a diagram showing the amino acid sequence of the light chain variable region of C3E-7034.

[Figure 24] Figure 24 is a diagram showing the amino acid sequence of CDR-H1 in C3E-7000.

[Figure 25] Figure 25 is a diagram showing the amino acid sequence of CDR-H2 in C3E-7000.

[Figure 26] Figure 26 is a diagram showing the amino acid sequence of CDR-H3 in C3E-7000.

[Figure 27] Figure 27 is a diagram showing the amino acid sequence of CDR-L1 in C3E-7000.

[Figure 28] Figure 28 is a diagram showing the amino

acid sequence of CDR-L2 in C3E-7000.

[Figure 29] Figure 29 is a diagram showing the amino acid sequence of CDR-L3 in C3E-7000.

[Figure 30] Figure 30 is a diagram showing the amino acid sequence of the light chain variable region of C3E-7035.

[Figure 31] Figure 31 is a diagram showing the amino acid sequence of C3E-7035.

[Figure 32] Figure 32 is a diagram showing the amino acid sequence of the light chain variable region of C3E-7036.

[Figure 33] Figure 33 is a diagram showing the amino acid sequence of C3E-7036.

[Figure 34] Figure 34 is a diagram showing a nucleotide sequence encoding C3E-7034.

[Figure 35] Figure 35 is a diagram showing a nucleotide sequence encoding C3E-7035.

[Figure 36] Figure 36 is a diagram showing a nucleotide sequence encoding C3E-7036.

[Figure 37] Figure 37 is a diagram showing the amino acid sequence of human CD3γ.

[Figure 38] Figure 38 is a diagram showing the amino acid sequence of C3E-7034.

[Figure 39] Figure 39 is a diagram showing the complex structure of CD3εγ and C3E-7034.

[Figure 40] Figure 40 is a pair of diagrams showing the interaction between CD3εγ and the heavy and light chains of C3E-7034.

Figure 40A is a diagram related to the light chain variable region of C3E-7034 and CD3ε in which the amino acid residues of CD3ε within a distance of 4 angstroms from each other are indicated by thick sticks in the model, and the other amino acids are indicated by thin sticks in the model.

Figure 40B is a diagram related to the heavy chain variable region of C3E-7034 and CD3ε in which the amino acid residues of CD3ε within a distance of 4 angstroms from each other are indicated by thick sticks in the model, and the other amino acids are indicated by thin sticks in the model.

[Figure 41] Figure 41 is a diagram showing the interaction sites of human CD3ε with the sequences of the heavy and light chain variable regions in C3E-7034.

[Figure 42] Figure 42 is a diagram showing the amino acid sequence of the heavy chain variable region in OKT3.

[Figure 43] Figure 43 is a diagram showing the amino acid sequence of the heavy chain variable region in C3E-3007.

[Figure 44] Figure 44 is a diagram showing the amino acid sequence of the light chain variable region in OKT3.

[Figure 45] Figure 45 is a diagram showing the amino acid sequence of the light chain variable region in C3E-3007.

[Figure 46] Figure 46 is a diagram showing a nucleotide sequence encoding C3E-3007 scFv.

[Figure 47] Figure 47 is a diagram showing the amino acid sequence of C3E-3007 scFv.

[Figure 48] Figure 48 is a diagram showing the binding activity of C3E-3007, C3E-7034, C3E-7035, and C3E-7036, which are humanized anti-CD3 scFvs, to human CD3 (PBMC).

[Figure 49] Figure 49 is a diagram showing the binding activity of C3E-3007, C3E-7034, C3E-7035, and C3E-7036, which are humanized anti-CD3 scFvs, to cynomolgus monkey CD3 (PBMC).

[Figure 50] Figure 50A is a diagram showing the activating effects of C3E-7034 and C3E-3007, which are humanized anti-CD3 scFvs, on human CD8-positive cells, and Figure 50B is a diagram showing the activating effects of C3E-7034 and C3E-3007, which are the humanized anti-CD3 scFvs, on cynomolgus monkey CD8-positive cells.

[Figure 51] Figure 51 is a diagram showing the amino acid sequence of HT1-11 scFv.

[Figure 52] Figure 52 is a diagram showing a nucleotide sequence encoding HT1-11 scFv.

[Figure 53] Figure 53 is a pair of diagrams showing that HT1-11 scFv binds to a human TROP2-positive cell line.

Figure 53A is a diagram showing binding to pharyngeal squamous cell cancer cell line FaDu.

Figure 53B is a diagram showing binding to pancreatic cancer cell line HPAF-II.

[Figure 54] Figure 54 is a diagram showing an ORF nucleotide sequence encoding T2C-0001.

[Figure 55] Figure 55 is a diagram showing an ORF nucleotide sequence encoding T2C-0003.

[Figure 56] Figure 56 is a diagram showing an ORF nucleotide sequence encoding T2C-0005.

[Figure 57] Figure 57 is a diagram showing an ORF nucleotide sequence encoding T2C-0006.

[Figure 58] Figure 58 is a diagram showing the amino acid sequence of T2C-0001.

[Figure 59] Figure 59 is a diagram showing the amino acid sequence of T2C-0003.

[Figure 60] Figure 60 is a diagram showing the amino acid sequence of T2C-0005.

[Figure 61] Figure 61 is a diagram showing the amino acid sequence of T2C-0006.

[Figure 62] Figure 62 is a pair of diagrams showing that anti-TROP2-CD3 bispecific molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 bind to a TROP2-positive cell line.

Figure 62A is a diagram showing binding to pharyngeal squamous cell cancer cell line FaDu.

Figure 62B is a diagram showing binding to pancreatic cancer cell line HPAF-II.

[Figure 63] Figure 63 is a diagram showing the binding activity of anti-TROP2-CD3 bispecific

molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 to human CD3 (PBMC).

[Figure 64] Figure 64 is a diagram showing the binding activity of anti-TROP2-CD3 bispecific molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 to cynomolgus monkey CD3 (PBMC).

[Figure 65]

Figure 65A is a diagram showing TROP2 expressed in pharyngeal squamous cell cancer cell line FaDu.

Figure 65B is a diagram showing TROP2 expressed in pancreatic cancer cell line HPAF-II.

Figure 65C is a diagram showing that TROP2 is not expressed in lung cancer cell line Calu-6.

[Figure 66]

Figure 66A is a diagram showing that anti-TROP2-CD3 bispecific molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 have cytotoxic activity against a pharyngeal squamous cell cancer cell line FaDu in the presence of human PBMC.

Figure 66B is a diagram showing that anti-TROP2-CD3 bispecific molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 have cytotoxic activity against pancreatic cancer cell line HPAF-II in the presence of human PBMC.

Figure 66C is a diagram showing that anti-TROP2-CD3 bispecific molecules T2C-0001, T2C-0003, T2C-0005, and T2C-0006 exhibit no cytotoxic activity against human lung cancer cell line Calu-6 in the

presence of human PBMC.

[Figure 67] Figure 67 is a diagram showing a nucleotide sequence encoding C3E-7078.

[Figure 68] Figure 68 is a diagram showing the amino acid sequence of C3E-7078.

[Figure 69] Figure 69 is a diagram showing a nucleotide sequence encoding C3E-7079.

[Figure 70] Figure 70 is a diagram showing the amino acid sequence of C3E-7079.

[Figure 71] Figure 71 is a diagram showing a nucleotide sequence encoding C3E-7085.

[Figure 72] Figure 72 is a diagram showing the amino acid sequence of C3E-7085.

[Figure 73] Figure 73 is a diagram showing a nucleotide sequence encoding C3E-7086.

[Figure 74] Figure 74 is a diagram showing the amino acid sequence of C3E-7086.

[Figure 75] Figure 75 is a diagram showing a nucleotide sequence encoding C3E-7087.

[Figure 76] Figure 76 is a diagram showing the amino acid sequence of C3E-7087.

[Figure 77] Figure 77 is a diagram showing a nucleotide sequence encoding C3E-7088.

[Figure 78] Figure 78 is a diagram showing the amino acid sequence of C3E-7088.

[Figure 79] Figure 79 is a diagram showing a nucleotide sequence encoding C3E-7089.

[Figure 80] Figure 80 is a diagram showing the amino

acid sequence of C3E-7089.

[Figure 81] Figure 81 is a diagram showing a nucleotide sequence encoding C3E-7090.

[Figure 82] Figure 82 is a diagram showing the amino acid sequence of C3E-7090.

[Figure 83] Figure 83 is a diagram showing a nucleotide sequence encoding C3E-7091.

[Figure 84] Figure 84 is a diagram showing the amino acid sequence of C3E-7091.

[Figure 85] Figure 85 is a diagram showing a nucleotide sequence encoding C3E-7092.

[Figure 86] Figure 86 is a diagram showing the amino acid sequence of C3E-7092.

[Figure 87] Figure 87 is a diagram showing a nucleotide sequence encoding C3E-7093.

[Figure 88] Figure 88 is a diagram showing the amino acid sequence of C3E-7093.

[Figure 89] Figure 89 is a diagram showing a nucleotide sequence encoding C3E-7094.

[Figure 90] Figure 90 is a diagram showing the amino acid sequence of C3E-7094.

[Figure 91] Figure 91 is a diagram showing a nucleotide sequence encoding C3E-7095.

[Figure 92] Figure 92 is a diagram showing the amino acid sequence of C3E-7095.

[Figure 93] Figure 93 is a diagram showing a nucleotide sequence encoding the primer HN53R Fw.

[Figure 94] Figure 94 is a diagram showing a

nucleotide sequence encoding the primer HN53R Rv.

[Figure 95] Figure 95 is a diagram showing a nucleotide sequence encoding the primer HN53S Fw.

[Figure 96] Figure 96 is a diagram showing a nucleotide sequence encoding the primer HN53S Rv.

[Figure 97] Figure 97 is a diagram showing an ORF nucleotide sequence encoding AXC-0001.

[Figure 98] Figure 98 is a diagram showing the amino acid sequence of AXC-0001.

[Figure 99] Figure 99 is a diagram showing an ORF nucleotide sequence encoding AXC-0002.

[Figure 100] Figure 100 is a diagram showing the amino acid sequence of AXC-0002.

[Figure 101] Figure 101 is a diagram showing an ORF nucleotide sequence encoding MGC-0001.

[Figure 102] Figure 102 is a diagram showing the amino acid sequence of MGC-0001.

[Figure 103] Figure 103 is a diagram showing an ORF nucleotide sequence encoding MGC-0002.

[Figure 104] Figure 104 is a diagram showing the amino acid sequence of MGC-0002.

[Figure 105] Figure 105 shows a list of primers used in the preparation of CDR variants of anti-CD3 antibodies.

[Figure 106-1] Figure 106-1 is a diagram showing the binding activity of CDR variants of anti-CD3 antibodies to human and cynomolgus monkey CD3 (PBMC).

[Figure 106-2] Figure 106-2 is a diagram showing the

binding activity of CDR variants of anti-CD3 antibodies to human and cynomolgus monkey CD3 (PBMC).

[Figure 107] Figure 107 is a diagram showing the expression of Axl in human lung cancer cell line A549 (A), human pancreatic cancer cell line PANC-1 (B), human pancreatic cancer cell line MIA PaCa-2 (C), human myeloma cell line U266B1 (D), and mantle cell lymphoma cell line Jeko-1 (E).

[Figure 108] Each of Figures 108A, 108B, and 108C is a diagram showing that anti-Axl CD3 bispecific molecules AXC-0001 and AXC-0002 have cytotoxic activity against Axl-expressing cell lines in the presence of human PBMC. Each of Figures 108D and 108E is a diagram showing that anti-Axl CD3 bispecific molecules AXC-0001 and AXC-0002 have no cytotoxic activity against non-Axl-expressing cell lines in the presence of human PBMC.

[Figure 109] Figure 109 is a diagram showing the binding activity of MAG-032 scFv in human lymphoblast fusion cell line T2 cells supplemented with MAGEC1 peptide (A) or DMSO (B).

[Figure 110]

Figure 110A is a diagram showing that anti-HLA-A2/MAGEC1-CD3 bispecific molecules MGC-0001 and MGC-0002 have cytotoxic activity against T2 cells supplemented with the MAGEC1 peptide in the presence of human PBMC.

Figure 110B is a diagram showing that anti-HLA-

A2/MAGEC1-CD3 bispecific molecules MGC-0001 and MGC-0002 have no cytotoxic activity against T2 supplemented with DMSO in the presence of human PBMC.

[Figure 111] Figure 111 is a diagram showing the amino acid sequence of MAGEC1 peptide.

[Figure 112] Figure 112 is a diagram showing the amino acid sequence in the CDRH2 region of a CDR variant. The first Xaa and the second Xaa each represent an arbitrary natural amino acid residue.

[Figure 113] Figure 113 is a diagram showing the amino acid sequence in the CDRL2 region of a CDR variant. Xaa represents an arbitrary natural amino acid residue.

[Figure 114] Figure 114 is a diagram showing the amino acid sequence of the variable region of the heavy chain of a CDR variant of C3E-7034. The first Xaa and the second Xaa each represent an arbitrary natural amino acid residue.

[Figure 115] Figure 115 is a diagram showing the amino acid sequence in the variable region of the light chain of a CDR variant of C3E-7034. Xaa represents an arbitrary natural amino acid residue.

[Figure 116] Figure 116 is a diagram showing the amino acid sequence in the variable region of the light chain of a CDR variant of C3E-7035. Xaa represents an arbitrary natural amino acid residue.

[Figure 117] Figure 117 is a diagram showing the amino acid sequence in the variable region of the

light chain of a CDR variant of C3E-7036. Xaa represents an arbitrary natural amino acid residue.

[Embodiment of the Invention]

[0012]

1. Definitions

In the present invention, the term "gene" means a nucleotide comprising a nucleotide sequence encoding the amino acids of a protein, or its complementary strand. "Gene" is meant to include, for example, a polynucleotide, an oligonucleotide, DNA, mRNA, cDNA, and cRNA as the nucleotide comprising a nucleotide sequence encoding the amino acids of a protein, or its complementary strand. Such a gene is a single-stranded, double-stranded, triple-stranded, or other multi-stranded nucleotide. "Gene" is also meant to include an aggregate of DNA and RNA strands, a mixture of ribonucleotides (RNAs) and deoxyribonucleotides (DNAs) on one nucleotide strand, and a double-stranded, triple-stranded or other multi-stranded nucleotide comprising such a nucleotide strand. In the present invention, the terms "base sequence" and "nucleotide sequence" have the same meaning.

[0013]

In the present invention, the term "polynucleotide" has the same meaning as "nucleic acid" and "nucleic acid molecule" and is also meant

to include, for example, any DNA, RNA, probe, oligonucleotide, and primer. Such a polynucleotide is a single-stranded, double-stranded, triple-stranded or other multi-stranded polynucleotide. The "polynucleotide" is also meant to include an aggregate of DNA and RNA strands, a mixture of ribonucleotides (RNAs) and deoxyribonucleotides (DNAs) on one polynucleotide strand, and an aggregate of two strands or three or more strands comprising such a polynucleotide strand.

[0014]

In the present invention, the terms "polypeptide," "peptide," and "protein" have the same meaning.

[0015]

In the present invention, the term "antigen" is sometimes used to mean "immunogen."

[0016]

In the present invention, the term "cell" also includes, for example, any cell derived from individual animals, subcultured cells, primary cultured cells, cell lines, recombinant cells, and microbial cells.

[0017]

In the present invention, the term "antibody" has the same meaning as immunoglobulin. However, the "antibody" used for the anti-CD3 antibody of the present invention means an immunoglobulin having

constant and variable regions. The antibody is not particularly limited and may be a natural immunoglobulin or may be an immunoglobulin produced by partial or complete synthesis. The anti-CD3 antibody of the present invention is included in "molecule" described below.

[0018]

The basic structure of a quaternary antibody is constituted by two identical light (L) chains and two identical heavy (H) chains. Each light chain is linked to a heavy chain by one covalent disulfide bond. The two heavy chains are linked to each other by one or more disulfide bonds depending on the isotypes of the heavy chains. Each of the light and heavy chains has regularly spaced intrachain disulfide bonds. Each of the heavy and light chains contains a constant region which exhibits a very high degree of amino acid sequence similarity and a variable region which exhibits a low degree of amino acid sequence similarity. The light chain has a variable region (VL) at the amino terminus followed by a constant region (CL). The heavy chain has a variable region (VH) at the amino terminus followed by three constant regions (CH1, CH2, and CH3). VL and VH are paired, and CL is aligned with the first constant region (CH1) of the heavy chain. VL and VH are paired to form a single antigen-binding site.

The constant regions of the antibody of the

present invention are not particularly limited. Preferably, constant regions derived from a human antibody are used in an antibody of the present invention for the treatment or prevention of diseases in humans. Examples of the heavy chain constant regions in the human antibody include Cγ1, Cγ2, Cγ3, Cγ4, Cμ, Cδ, Cα1, Cα2, and Cε. Examples of light chain constant regions in the human antibody include Cκ and Cλ.

[0019]

Fab is composed of heavy chain CH1 followed by VH, and light chain CL followed by VL. VH and VL each contain complementarity determining regions (CDRs).

[0020] Fc is constituted by the carboxyl-terminal regions of the heavy chain constant regions and is a dimer containing CH2 and CH3. The Fc of the present invention may be Fc having a natural sequence or may be a mutated form of Fc containing a mutation in the natural sequence.

[0021]

The variable region is composed of regions, called hypervariable regions (HVRs), having extreme variability, and relatively invariable regions, called framework regions (FRs), interrupted by hypervariable regions. The natural heavy and light chain variable regions each contain four FRs connected by three hypervariable regions. The hypervariable regions of each chain are kept in close

proximity together with the hypervariable regions of another chain by FRs and contribute to the formation of an antigen-binding site in the antibody.

[0022]

The heavy and light chains of an antibody molecule are known to each have three complementarity determining regions (CDRs). The complementarity determining regions are also called hypervariable domains. These regions are located in the variable regions of the antibody heavy and light chains. These sites have a particularly highly variable primary structure and are usually separated at three positions on the respective primary structures of heavy and light chain polypeptide strands. In the present invention, the complementarity determining regions of the antibody are referred to as CDRH1, CDRH2, and CDRH3 from the amino terminus of the heavy chain amino acid sequence for the complementarity determining regions of the heavy chain and as CDRL1, CDRL2, and CDRL3 from the amino terminus of the light chain amino acid sequence for the complementarity determining regions of the light chain. These sites are close to each other in the three-dimensional structure and determine specificity for the antigen to be bound.

[0023]

In the present invention, the positions and lengths of CDRs were determined according to IMGT

definitions (Developmental and Comparative Immunology 27 (2003) 55-77).

[0024]

The framework regions (FRs) are variable regions except for CDR residues. Each variable region usually has four FRs, namely, FR1, FR2, FR3, and FR4.

0025]

The positions of CDRs and FRs can also be determined according to other definitions well known in the art, for example, IMGT definitions as well as Kabat, Chothia, AbM, and contact definitions.

[0026]

In the present invention, the term "antigen-binding fragment of the antibody" means a partial antibody fragment that has heavy and light chain variable regions and has binding activity to an antigen. Examples of the "antigen-binding fragments in the antibody" include, but are not limited to, antigen-binding fragments such as Fab, $F(ab')_2$, scFv, Fab', Fv, and single-domain antibody (sdAb). Such an antigen-binding fragment of an antibody may be obtained by treating a full-length molecule of an antibody protein with an enzyme such as papain or pepsin, or may be a recombinant protein produced in an appropriate host cell using a recombinant gene.

[0027]

In the present invention, the "site" to which an antibody is bound, i.e., the "site" recognized by

an antibody, means a partial peptide or partial higher-order structure on an antigen that is bound or recognized by the antibody.

[0028]

In the present invention, such a site is also referred to as an epitope or an antibody binding site.

In the present invention, the term "antibody mutant" means a polypeptide that has an amino acid sequence derived from the amino acid sequence of the original antibody by substitution, deletion, and/or addition ("addition" includes insertion) (hereinafter, collectively referred to as a "mutation") of amino acid(s) and binds to the CD3 of the present invention. The number of mutated amino acids in such an antibody mutant is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30, 40, or 50. Such an antibody mutant can be "antibody" of the present invention.

[0029]

In the present invention, the term "more" in "1 or more" refers to a number from 2 to 10.

[0030]

In the present specification, the term "molecule" is a molecule comprising the aforementioned antibody or antigen-binding fragment of the antibody and also includes multispecific molecules formed by antibodies or a plurality of antigen-binding fragments derived therefrom.

[0031]

In the present specification, the term "molecule which is multispecific" has the same meaning as a "multispecific molecule." Such a multispecific molecule is not particularly limited as long as the molecule is capable of binding to a plurality of epitopes different from each other on one molecule, and/or epitopes different from each other on two or more molecules. A molecule which is multispecific also includes an antibody comprising heavy chain variable (VH) and light chain variable (VL) regions. Examples of such multispecific molecules include, but are not limited to, a full-length antibody molecule having two or more types of heavy chains and two or more types of light chains, i.e., an IgG-type multispecific molecule, and a molecule consisting of two or more types of antigen-binding fragments having VLs and VHs, i.e., a molecule derived by a combination of Fab, Fab', Fv, scFv, sdAb, etc. (i.e., tandem scFv, diabodies, single chain diabodies, and triabodies). In addition, a molecule formed by genetically or chemically linking a protein having antigen binding activity without an immunoglobulin skeleton, to an antigen-binding fragment is also included in the multispecific molecule.

[0032]

Examples of activities or properties realized

by an anti-CD3 antibody of the present invention, an antigen-binding fragment of an antibody of the present invention, or a multispecific molecule of the present invention can include biological activities or physicochemical properties and can specifically include various biological activities, binding activity against an antigen or an epitope, stability during production or storage, and thermal stability. [0033]

In the present invention, the phrase "hybridizing under stringent conditions" means hybridization under conditions involving hybridization at 65°C in a solution containing 5 × SSC, followed by washing at 65°C for 20 minutes in an aqueous solution containing 2 × SSC-0.1% SDS, at 65°C for 20 minutes in an aqueous solution containing 0.5 × SSC-0.1% SDS, and at 65°C for 20 minutes in an aqueous solution containing 0.2 × SSC-0.1% SDS, or hybridization under equivalent conditions. SSC means an aqueous solution of 150 mM NaCl-15 mM sodium citrate, and n × SSC means SSC with n times the concentration.[0034]

In the present invention, the term "cytotoxicity" refers to some pathological change brought about in cells and means not only direct trauma but any structural or functional damage to cells, including DNA cleavage, formation of base dimers, chromosomal breaks, damage to mitotic

apparatus, and reductions in the activities of various enzymes.

In the present invention, the term "cytotoxic activity" means activity that causes the cytotoxicity mentioned above.

[0035]

In the present invention, the term "antibody dependent cellular cytotoxicity (ADCC) activity" means the effect or activity of damaging target cells such as tumor cells by NK cells via antibodies.

[0036]

In the present invention, the term "cytotoxic activity by the redirection of T cells" means the cytotoxicity is caused by a multispecific molecule comprising an anti-tumor antigen antibody and an anti-CD3 antibody. Specifically, the term means that the anti-tumor antigen antibody binds to a target tumor cell while the anti-CD3 antibody binds to a T cell so that the target tumor cell and the T cell come closer to each other to induce T cell activation-mediated cytotoxicity. The molecule can be contained in a pharmaceutical composition.

2. Antigenic protein CD3 (CD3 complex)

In the present invention, the term "CD3" has the same meaning as CD3 protein.

[0037]

CD3 is expressed, as a portion of a

multimolecular T cell receptor complex, on T cells and is a complex of 5 types of polypeptide (γ, δ, ε, ζ, and η) chains (with molecular weights 25000 to 28000, 21000, 20000, 16000, and 22000, respectively).

[0038]

The CD3 used in the present invention can be prepared by purification or isolation from animal tissues (including body fluids), cells derived from tissues, or cultures of cells, gene recombination, *in vitro* translation, chemical synthesis, etc.

[0039]

The nucleotide sequence of a cDNA encoding human CD3ε is registered with GenBank under Accession No. NM_000733.3. The nucleotide sequence of a cDNA encoding cynomolgus monkey CD3 is registered with GenBank under Accession No. NM_001283615.1. The amino acid sequence of human CD3ε is described in SEQ ID NO: 1 of the Sequence Listing.

[0040]

The CD3ε cDNA can be obtained using, for example, using the so-called PCR method in which a polymerase chain reaction (hereinafter, referred to as "PCR") (Saiki, R.K., et al., Science (1988) 239, 487-489) is performed using a cDNA library from CD3ε mRNA-expressing organs as a template and using primers capable of specifically amplifying the CD3ε cDNA.

[0041]

A nucleotide sequence encoding a protein that

consists of an amino acid sequence derived from the amino acids of CD3 by the substitution, deletion, or addition of 1 or more amino acids and has biological activities equivalent to CD3 is also included in the nucleotide sequence of the CD3 gene. A protein that consists of an amino acid sequence derived from the amino acid sequence of CD3 by the substitution, deletion, or addition of 1 or more amino acids and has biological activities equivalent to CD3 is also included in the CD3.

[0042]

A polynucleotide hybridized under stringent conditions to a polynucleotide consisting of a nucleotide sequence complementary to the nucleotide sequence encoding human or cynomolgus monkey CD3ε, and encoding a protein having biological activities equivalent to CD3ε is also included in the CD3ε cDNA. In addition, splicing variants transcribed from human or cynomolgus monkey CD3ε gene loci, or polynucleotides hybridized thereto under stringent conditions and encoding a protein having biological activities equivalent to CD3ε are also included in the CD3ε cDNA.

[0043]

3. Anti-CD3 antibody

(3-1) Classification of antibody

An anti-CD3 antibody of the present invention and an antigen-binding fragment of the antibody

(hereinafter, also referred to as the antibody, etc. of the present invention) may be either a monoclonal or a polyclonal antibody. Examples of monoclonal antibodies of the present invention include non-human animal-derived antibodies (non-human animal antibodies), human antibodies, chimeric antibodies, and humanized antibodies.

[0044]

Examples of non-human animal antibodies include antibodies derived from vertebrates such as mammals and birds. Examples of the mammal-derived antibodies include rodent-derived antibodies such as mouse antibodies and rat antibodies. Examples of bird-derived antibodies include chicken antibodies. An example of an anti-human CD3 rat monoclonal antibody is C3-147 [Example 1)-7] of the present invention.

[0045]

Examples of chimeric antibodies include, but are not limited to, antibodies comprising non-human animal antibody-derived variable regions bound to human antibody (human immunoglobulin) constant regions.

[0046]

Examples of humanized antibodies can include, but are not limited to, human antibodies (human immunoglobulin variable regions) grafted to CDRs in variable regions of non-human animal antibodies, a human antibody grafted to CDRs as well as to partial

sequences of framework regions in non-human animal antibodies, and antibodies having human antibody amino acids substituted for one or more non-human animal antibody-derived amino acids in any of these humanized antibodies. Examples of CDRs in variable regions of non-human animal antibodies include CDRH1 to CDRH3 in the heavy chain variable region and CDRL1 to CDRL3 in the light chain variable region derived from rat anti-CD3 antibody C3E-7000 of the present invention, and CDRs derived from the amino acid sequences of these CDRs by substitution of 1 or 2 amino acids by different amino acids.

[0047]

The human antibody is not particularly limited as long as the antibody preferably binds to human CD3 and more preferably binds to human CD3 and to cynomolgus monkey CD3. Examples also include human antibodies binding to the same site as in the humanized antibodies of the present invention. Examples include human antibodies binding to the same site as C3E-7034.

[0048]

Preferably, the antibody, etc. of the present invention binds to human CD3. More preferably, the antibody, etc. of the present invention also has binding activity to cynomolgus monkey CD3.

[0049]

The antibody, etc. of the present invention may

be comprised of portions derived from a plurality of different antibodies as long as the antibody binds to human CD3 and also binds to cynomolgus monkey CD3. Examples of these antibodies include antibodies comprising heavy and/or light chains exchanged among a plurality of different antibodies, antibodies comprising full-length heavy and/or light chains exchanged among themselves, antibodies comprising variable or constant regions exchanged among themselves, and antibodies comprising all or some CDRs exchanged among themselves. The heavy and light chain variable regions of a chimeric antibody may be derived from different antibodies of the present invention. CDRH1 to CDRH3 and CDRL1 to CDRL3 in the heavy and light chain variable regions of the humanized antibody may be derived from two or more different antibodies of the present invention. CDRH1 to CDRH3 and CDRL1 to CDRL3 in the heavy and light chain variable regions of the human antibody may be a combination of CDRs carried by two or more different antibodies of the present invention.

[0050]

Examples of the isotype of the monoclonal antibody of the present invention can include, but are not particularly limited to, IgGs such as IgG1, IgG2, IgG3, and IgG4, IgM, IgAs such as IgA1 and IgA2, IgD, and IgE.

[0051]

The isotype and subclass of the monoclonal antibody can be determined using, for example, an Ouchterlony test, an enzyme-linked immunosorbent assay (ELISA), or a radio immunoassay (RIA). A commercially available kit for identification (e.g., Rat Immunoglobulin Isotyping ELISA Kit (BD Pharmingen) may be used.

[0052]

(3-2) Binding specificity of anti-CD3 antibody

The antibody, etc. of the present invention recognizes CD3. In other words, the antibody, etc. of the present invention binds to CD3. The antibody, etc. of the present invention preferably binds to human CD3 and to monkey CD3, and more preferably binds to human CD3 and to cynomolgus monkey CD3.

[0053]

More specifically, the antibody of the present invention and antigen-binding fragment thereof, and their variable regions, bind to an Ig-like domain present in the extracellular region of the ε chain (Figure 1, SEQ ID NO: 1) of the human CD3 complex. Furthermore, these also bind to an Ig-like domain present in the extracellular region of the ε chain of the cynomolgus monkey CD3 complex.

[0054]

Epitopes present in the extracellular region of the ε chain (Figure 1, SEQ ID NO: 1) of the human CD3 complex bound by the antibody, etc. of the present

invention contain the following amino acids: Ser55, Glu56, Leu58, Trp59, Asn65, Ile66, Ser77, Asp78, Arg101, Gly102, Ser103, Lys104, and Pro105.

[0055]

Preferably, the antibody, etc. of the present invention can maintain binding to human CD3 by binding to an epitope region containing at least 7 amino acids selected from these 13 amino acids.

[0056]

When an antibody is adjacent to these amino acids within a distance of 4 angstroms, such an antibody can be confirmed to have the same epitope specificity as that of the antibody, etc. of the present invention. On the other hand, among epitope amino acids Arg101, Gly102, Ser103, Lys104, and Pro105 are present epitope residues that interact with anti-CD3 antibody OKT3 or UCHT1 as known in the art (Lars Kjer-Nielsen et al., PNAS (2004); and Kelly L Arnett et al., PNAS (2004)). However, OKT3 or UCHT1 binds to human CD3, but does not bind to cynomolgus monkey CD3.

[0057]

In the present invention, "recognition," i.e., "binding," means binding which is not non-specific adsorption. Examples of criteria for determining whether recognition is achieved or not, i.e., binding is achieved or not, can include a dissociation constant (hereinafter, referred to as "K_D").

Preferably, the antibody, etc. of the present invention has a K_D value of 1×10^{-5} M or lower, 5×10^{-6} M or lower, 2×10^{-6} M or lower, or 1×10^{-6} M or lower for CD3.

[0058]

In the present invention, the binding of the antibody to the antigen can be assayed or determined using a biomolecular interaction analysis system (e.g., SPR or BLI), ELISA, or RIA. The binding of the antibody to the antigen expressed on a cell surface can be assayed by flow cytometry.

[0059]

The SPR (surface plasmon resonance analysis) method is used as an analytical approach for determining a dissociation constant (KD value), etc. as an index for affinity by measuring the association rate constant (ka value) and the dissociation rate constant (kd value) by kinetic analysis. Examples of equipment used in SPR analysis include BIAcore(TM) (manufactured by GE Healthcare), ProteOn(TM) (manufactured by Bio-Rad Laboratories,), SPR-Navi(TM) (manufactured by BioNavis), Spreeta(TM) (manufactured by Texas Instruments Inc.), SPRi-Plex II(TM) (manufactured by Horiba, Ltd.), and Autolab SPR(TM) (manufactured by Metrohm).

[0060]

BLI (biolayer interferometry) is a method which involves measuring biomolecular interactions using

biolayer interference. Examples of equipment used in BLI interaction analysis include the Octet system (manufactured by Pall ForteBio Corp.).

[0061]

ELISA is a method which involves capturing an antigen or an antibody of interest contained in a sample solution using a specific antibody or antigen, while detecting and quantifying the antigen or antibody of interest through the use of enzymatic reaction. An enzyme-labeled antigen or antibody is incorporated into the reaction system, and the enzyme activity is detected. For enzyme activity detection, a substrate whose absorption spectrum is changed by the reaction is used, and the absorption spectrum is digitized by absorbance measurement.

[0062]

Cell-ELISA is a method which involves capturing an analyte on the cell surface on a cell-by-cell basis, while detecting and quantifying the analyte through the use of an enzymatic reaction.

[0063]

RIA (radio immunoassay) can quantify an antibody by labeling the antibody with a radioactive material and measuring radioactivity from the antibody.

[0064]

Flow cytometry is an approach used to optically analyze individual cells by dispersing fine cells in

a fluid and streaming a thin stream of the fluid. A fluorescent dye-labeled antibody binds to the cell surface of an antigen through an antigen-antibody reaction, and the number of cells bound to the antibody is measured using fluorescence intensity which indicates the antigen binding activity of the antibody.

As mentioned above, an antibody, etc. binding to human CD3 and to cynomolgus monkey CD3 can be subjected to various tests of efficacy or safety using primates, particularly, cynomolgus monkeys, which is essential for the nonclinical development (preclinical development) of pharmaceutical products and thus preferred. Also, an antibody, etc. binding to human CD3 and to cynomolgus monkey CD3 has cytotoxic activity and is useful, either alone or as a molecule of the present invention, in the treatment or prevention of diseases such as cancers in humans and cynomolgus monkeys. Pharmaceutical compositions are described below.

[0065]

An antibody, etc. of the present invention binding to human CD3 and to cynomolgus monkey CD3 does not bind to mouse CD3. Therefore, various assays or immunohistochemical tests using human CD3 gene-transfected mouse cells, tissues, or individuals (including transgenic animals, knock-out animals, and knock-in animals) and the antibody, etc. can be

carried out without being influenced by the CD3 of the host mice. Thus, the antibody, etc. is preferred for use in research and nonclinical development on mice of drugs, animal drugs, and diagnostic drugs comprising the antibody, etc.

(3-3) Monoclonal antibody

The present invention provides monoclonal antibodies. These monoclonal antibodies include, for example, non-human animal-derived monoclonal antibodies such as rat, mouse, rabbit, chicken, and fish antibodies, chimeric antibodies, humanized antibodies, human antibodies, antigen-binding fragments thereof, antibody mutants of these antibodies or antigen-binding fragments, and variants of these antibodies or antigen-binding fragments.

[0066]

For example, C3-147 obtained by the method described in Example 1 is an anti-CD3 rat monoclonal antibody.

[0067]

The nucleotide sequence of a DNA encoding the heavy chain variable region of C3-147 is described in SEQ ID NO: 6 (Figure 14) of the Sequence Listing, and its amino acid sequence is described in SEQ ID NO: 7 (Figure 15). The nucleotide sequence of a DNA encoding the light chain variable region of C3-147

is described in SEQ ID NO: 8 (Figure 16) of the Sequence Listing, and its amino acid sequence is described in SEQ ID NO: 9 (Figure 17).

[0068]

The antibody mutant of the present invention preferably may exhibit, for example, reduced sensitivity to protein degradation or oxidation, improved or maintained biological activities or functions, suppressed reduction or deterioration of such biological activities or functions, an improved ability to bind to antigen(s), or physicochemical or functional properties imparted thereto. It is commonly known that a side chain of a specific amino acid in a protein can be altered, thereby altering an activity or function of the protein. Examples of such alterations include deamidation of a side chain of aspartate and isomerization of a side chain of aspartate. Antibody mutants of the present invention include those in which one or more amino acids are substituted with other amino acids to prevent such alterations.

[0069]

Examples of these antibody mutants of the present invention include antibodies having an amino acid sequence derived from the amino acid sequence of the original antibody by conservative amino acid substitution. Conservative amino acid substitution is substitution that occurs in an amino acid group

related to amino acid side chains.

[0070]

Preferred amino acid groups are as follows: an acidic group including aspartic acid and glutamic acid; a basic group including lysine, arginine, and histidine; a nonpolar group including alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, and tryptophan; and an uncharged polar family including glycine, asparagine, glutamine, cysteine, serine, threonine, and tyrosine. Other preferred amino acid groups are as follows: an aliphatic hydroxy group including serine and threonine; an amide-containing group including asparagine and glutamine; an aliphatic group including alanine, valine, leucine, and isoleucine; and an aromatic group including phenylalanine, tryptophan, and tyrosine. Amino acid substitution in an antibody mutant is preferably performed without reducing the antigen binding activity of the original antibody.

[0071]

The present invention also encompasses an antibody mutant having an amino acid sequence, which is derived from the amino acid sequence composed of an antibody or antigen-binding fragment thereof according (1) mentioned above, e.g., C3-147, in which a conservative amino acid substitution and/or some other amino acid mutation occurs (or is performed);

a mouse antibody, a rat antibody, a chimeric antibody, a humanized antibody, or a human antibody composed of CDRs having an amino acid sequence in which a conservative amino acid mutation and/or some other amino acid mutation occurs (or is performed) in the amino acid sequence of any of CDRH1 to CDRH3 and CDRL1 to CDRL3 derived from an antibody or antigen-binding fragment thereof according (1) mentioned above, e.g., C3-147; an antigen-binding fragment of any of these antibody mutants and mutated antibodies; and a molecule comprising such an antibody mutant, mutated antibodies or antigen-binding fragment thereof.

[0072]

(3-4) Antigen-binding fragment of anti-CD3 antibody

According to one aspect, the present invention provides an antigen-binding fragment of an anti-CD3 antibody of the present invention. An antigen-binding fragment of the antibody means a fragment that maintains at least antigen binding activity among the functions of the antibody, or a variant thereof. Examples of functions of the antibody generally include antigen binding activity, antigen activity-regulating activity, antibody dependent cellular cytotoxic activity, and complement dependent cytotoxic activity. Examples of functions of an antibody, etc. of the present invention and a

multispecific molecule comprising the antibody, etc. of the present invention include the redirection of T cells, the activation of T cells, and cytotoxic activity against cancer cells by the activation of T cells.

[0073]

The antigen-binding fragment of the antibody is not particularly limited as long as the fragment of the antibody maintains at least antigen binding activity among the activities of the antibody. Examples include, but are not limited to, Fab, Fab', $F(ab')_2$, Fv, single chain Fv (scFv) comprising heavy and light chain Fvs linked via an appropriate linker, and single domain antibody (sdAb). The antigen-binding fragment of the antibody of the present invention is also meant to include a molecule comprising the antigen-binding fragment of the antibody of the present invention as well as other portions, such as scFv retaining a linker portion.

[0074]

A molecule that is derived from an antibody protein by the deletion of 1 or more or more amino acids at its amino terminus and/or carboxyl terminus and retains at least a portion of the functions of the antibody is also encompassed in the meaning of the antigen-binding fragment of the antibody. Such a variant of an antigen-binding fragment of an antibody is also encompassed by the antibody of the present

invention or antigen-binding fragment thereof, or a variant (described later) of the antibody or antigen-binding fragment.

[0075]

According to one aspect, the antigen-binding fragment of the antibody of the present invention is scFv. The scFv is obtained by linking the heavy and light chain variable regions of the antibody via a polypeptide linker (Pluckthun A., The Pharmacology of Monoclonal Antibodies 113, Rosenburg and Moore, ed., Springer Verlag, New York, 269-315 (1994); and Nature Biotechnology (2005), 23, 1126-1136). Also, tandem scFv comprising two scFvs linked via a polypeptide linker can be used as a bispecific molecule. Alternatively, triabodies and such comprising three or more scFvs may be used as a multispecific molecule.

[0076]

The antibody of the present invention may be an antibody that has a single heavy chain variable region and has no light chain sequence. Such an antibody, called a single domain antibody (sdAb) or a nanobody, has been reported to retain the ability to bind to an antigen (Muyldemans S. et al., Protein Eng., (1994), 7 (9), 1129-35; and Hamers-Casterman C. et al., Nature (1993), 363 (6428), 446-448). These antibodies are also encompassed in the meaning of an antigen-binding fragment of an antibody according to

the present invention.

[0077]

The present invention also includes a single chain immunoglobulin comprising full-length heavy and light chain sequences of the antibody linked via an appropriate linker (Lee, H-S, et al., Molecular Immunology (1999) 36, 61-71; and Shirrmann, T. et al., mAbs (2010), 2 (1), 1-4). Such a single chain immunoglobulin can be dimerized to retain a structure and activities similar to those of the antibody, which is originally a tetramer.

[0078]

(3-5) Molecules having antigen binding activity

The molecule of the present invention comprises the anti-CD3 antibody of the present invention or antigen-binding fragment thereof.

[0079]

The molecule of the present invention can further comprise, for example, a signal sequence, a tag for purification, amino-terminal Gly, a drug linker portion of ADC, an albumin-binding polypeptide, a polymer such as PEG, an antibody other than the anti-CD3 antibody, an antigen-binding fragment thereof, and a protein having antigen binding activity without having an immunoglobulin skeleton, which will be described below.

[0080]

The molecule of the present invention binds to

human CD3 and to cynomolgus monkey CD3.

[0081]

The molecule of the present invention includes a multispecific molecule described below.

[0082]

The molecule of the present invention may be a form of being introduced in to a cell or a form of being displayed on the cell surface, such as CAR-T, etc.

[0083]

(3-6) Multispecific molecules and bispecific molecules

The multispecific molecule of the present invention is a molecule having two or more antigen-binding sites. Specifically, the multispecific molecule of the present invention is a molecule capable of binding to two or more epitopes different from each other on one molecule, or epitopes different from each other on two or more molecules, and comprises a plurality of antigen-binding fragments different from each other. Examples of multispecific molecules include, but are not limited to, IgG-type multispecific molecules and multispecific molecules having two or more types of variable regions, for example, antibody fragments such as tandem scFv, single-chain diabodies, diabodies, triabodies, and antibody fragments linked by a covalent bond or a noncovalent bond. The

multispecific molecule may contain Fc.

[0084]

A multispecific molecule of the present invention comprises an anti-CD3 antibody of the present invention or antigen-binding fragment of the antibody. The multispecific molecule of the present invention comprises an antibody, etc. of the present invention and 1 or 2 or more additional antibodies or antigen-binding fragments of antibodies. Examples of an antigen-binding fragment of an antibody include Fab, F(ab)', Fv, scFv, and sdAb.

[0085]

The multispecific molecule of the present invention specifically binds to CD3 or may further bind to a target such as an Fc receptor on effector cells.

[0086]

Preferred examples of multispecific molecules of the present invention include bispecific molecules. The term "bispecific" means of the ability to bind to two epitopes different from each other on one molecule, or epitopes different from each other on two molecules. An antibody or an antigen-binding fragment having such bispecificity is encompassed by the present invention. A bispecific molecule of the present invention binds to CD3 and binds to an epitope that is absent from CD3 but present in another antigen. More specifically, such a bispecific

molecule (i) binds to an epitope on CD3 (epitope 1) and (ii) binds to an epitope different from the epitope 1 on CD3 (epitope 2), or binds to an epitope on an antigen other than CD3 (epitope 3).

[0087]

For example, in a tandem scFv-type bispecific molecule typified by BiTE, an antigen-binding site in the heavy chain variable region of a first antibody and an antigen-binding site in the light chain variable region of the first antibody are linked either via a linker or directly without a linker to form a first polypeptide. Also, an antigen-binding site in the heavy chain variable region of a second antibody and an antigen-binding site in the light chain variable region of the second antibody are linked either via a linker or directly without a linker to form a second polypeptide. The first polypeptide and the second polypeptide are linked either via a linker or directly without a linker. Alternatively, the first polypeptide and the second polypeptide may be linked via an additional molecule.

[0088]

In a diabody-type bispecific molecule, an antigen-binding site in the heavy chain variable region of a first antibody and an antigen-binding site in the light chain variable region of a second antibody are linked either via a linker or directly without a linker. Also, an antigen-binding site in

the light chain variable region of the first antibody and an antigen-binding site in the heavy chain variable region of the second antibody are linked either via a linker or directly without a linker. Also, a bispecific molecule may be prepared by the further dimerization of diabody-type bispecific molecules. In addition, the diabody-type bispecific molecule may be linked to one single chain or both chains of Fc via a linker (diabody-Fc-type bispecific molecule).

[0089]

In a dual scFv-type bispecific molecule, two scFvs to be bound to different epitopes are linked to the two chains of dimeric Fc, either via linkers or directly without linkers. Alternatively, two types of scFvs to be bound to different epitopes are linked to CH and CL, respectively, via linkers and further linked to two chains of dimeric Fc, respectively, via linkers.

In an IgG-type bispecific molecule, two Fabs to be bound to different epitopes are linked to the two chains of dimeric Fc, either via linkers or directly without linkers.

Alternatively, a bispecific molecule of the present invention may be a bispecific antibody in which Fab and scFv to be bound to different epitopes are linked to the two chains of dimeric Fc, either via linkers or directly without linkers.

Alternatively, a bispecific molecule of the present invention may be a bispecific molecule in which Fab in the first antibody and scFv in the second antibody are linked to the two chains of dimeric Fc via linkers.

[0090]

The scFv and the Fab contained in a bispecific molecule of the present invention are preferably scFv and Fab of a humanized antibody or a human antibody, and the Fc is preferably Fc of a human antibody.

[0091]

In a variable reagion comprised in a bispecific antibody of the present invention, a heavy chain variable region and a light chain variable region can bind in this order, or a light chain variable region and a heavy chain variable region can bind in this order, from the amino-terminal. A bispecific antibody of the present invention optionally has a linker between both variable regions, and can (optionally) have a glycine residue at the amino-termin of a variable region which is placed on the amino terminal side. A bispecific antibody of the tandem scFv type of the present invention optionally has a linker, FLAG-tag, and/or HIS-tag at the carboxyl terminus of a variable region which is placed on the carboxyl terminal side. Preferable examples of bispecific antibodies of the present invention include a bispecific antibody, in which a heavy chain variable region, a first linker, a light

chain variable region, a second linker, a FLAG-tag, and His-tag bound in this order from amino terminus.

[0092] The linker also includes a single chain polypeptide or a single chain oligopeptide, or synthetic products such as PEG, nucleotides, sugar chains, and compounds. In addition, any linker known in the art may be used without particular limitations as long as the linker links two polypeptides.

[0093]

The length of the linker is from 5 to 30 amino acids for, for example, a peptide linker. When the bispecific molecule contains a plurality of linkers, all the peptide linkers used may have the same length or the peptide linkers used may have different lengths.

[0094]

An example of a peptide linker is a (Gly·Gly·Gly·Gly·Ser) repeating unit. One or more amino acid residues other than Gly and Ser may be added.

[0095]

(3-7) Humanized anti-CD3 antibodies

According to one aspect, the present invention provides a humanized anti-CD3 antibody or an antigen-binding fragment thereof.

[0096]

Examples of humanized antibodies of the present invention include human-derived antibodies containing only complementarity determining regions

(CDRs) (Nature (1986) 321, 522-525), and human antibodies grafted to CDR sequences and to some amino acid residues of framework regions by CDR grafting (International Publication No. WO1990/07861A1).

[0097]

Preferably, the heavy chain variable region contained in a humanized anti-CD3 antibody of the present invention or an antigen-binding fragment of the antibody retains

CDRH1 consisting of the amino acid sequence represented by SEQ ID NO: 26 (Figure 24) (GVTFNYYG), andCDRH2 consisting of the amino acid sequence represented by SEQ ID NO: 98 (Figure 112) (IT Xaa Xaa GGRI) (wherein the first Xaa and the second Xaa each represent an arbitrary natural amino acid residue. Hereinafter, the first Xaa is also referred to as X_1, and the second Xaa is also referred to as X_2.), and CDRH3 consisting of the amino acid sequence represented by SEQ ID NO: 28 (Figure 26) (TLDGRDGWVAY).

[0098]

Also preferably, the light chain variable region contained in a humanized anti-CD3 antibody of the present invention or an antigen-binding fragment of the antibody retains

CDRL1 consisting of the amino acid sequence represented by SEQ ID NO: 29 (Figure 27) (TGNIGSNY), CDRL2 consisting of the amino acid sequence

represented by SEQ ID NO: 99 (Figure 113) (R Xaa D) (wherein Xaa represents an arbitrary natural amino acid residue. Hereinafter, Xaa of CDRL2 is also referred to as X_3.), and
CDRL3 consisting of the amino acid sequence represented by SEQ ID NO: 31 (Figure 29) (QSYSSGFI).

[0099]

In CDRH2 (ITX_1X_2GGRI) mentioned above, preferably, X_1 is selected from a group consisting of A, E, G, H, I, L, T, V, R, and S, and X_2 is S; or X_1 is N, and X_2 is selected from a group consisting of E, R, F, Y, L, V, I, K, and T.

In CDRL2 (RX_3D) mentioned above, preferably, X_3 is selected from a group consisting of Q, A, G, S, N, and D.

[0100]

In CDRH2 (ITX_1X_2GGRI) mentioned above, more preferably, X_1 is selected from a group consisting of R and S, and X_2 is S.

In CDRL2 (RX_3D) mentioned above, more preferably, X_3 is selected from a group consisting of Q, A, G, S, N, and D.

[0101]

Preferred examples of heavy chain variable regions contained in such humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include a heavy chain variable region comprising the amino acid

residues represented by SEQ ID NO: 100 (Figure 114).

[0102]

Also, preferred examples of light chain variable regions contained in humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include

a light chain variable region comprising the amino acid residues represented by SEQ ID NO: 101 (Figure 115), SEQ ID NO: 102 (Figure 116), or SEQ ID NO: 103 (Figure 117).

[0103]

Specific preferred examples of heavy chain variable regions contained in humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include

a heavy chain variable region which retains

CDRH1 consisting of the amino acid sequence represented by SEQ ID NO: 26 (Figure 24) (GVTFNYYG),

CDRH2 consisting of the amino acid sequence represented by SEQ ID NO: 27 (Figure 25) (ITNSGGRI), and

CDRH3 consisting of the amino acid sequence represented by SEQ ID NO: 28 (Figure 26) (TLDGRDGWVAY).

[0104]

Specific preferred examples of light chain variable regions contained in humanized anti-CD3 antibodies of the present invention or antigen-

binding fragments of the antibody include
a light chain variable region which retains
CDRL1 consisting of the amino acid sequence represented by SEQ ID NO: 29 (Figure 27) (TGNIGSNY), CDRL2 consisting of the amino acid sequence represented by SEQ ID NO: 30 (Figure 28) (RDD), and CDRL3 consisting of the amino acid sequence represented by SEQ ID NO: 31 (Figure 29) (QSYSSGFI).

[0105]

In the present invention, the positions and lengths of CDRs were determined according to IMGT definitions (Developmental and Comparative Immunology 27 (2003) 55-77).

[0106]

Specific examples of heavy chain variable regions of the present invention include amino acid sequence comprising amino acid residues of SEQ ID NO: 16.

[0107]

Specific examples of light chain variable regions of the present invention include an amino acid sequence comprising amino acid residues of SEQ ID NO: 17, 20 or 23.

[0108]

Specific preferred examples of humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include
an antibody or an antigen-binding fragment of the

antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 60 and a light chain variable region comprising the 135th through 241st amino acid residues of SEQ ID NO: 60,

an antibody or an antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 64 and a light chain variable region comprising the 135th through 241st amino acid residues of SEQ ID NO: 64,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 66 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 66,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 68 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 68,

an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 70 and a light chain variable region comprising the 135th through 243rd amino acid

residues of SEQ ID NO: 70,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 72 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 72,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 74 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 74,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 76 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 76,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 78 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 78,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues

of SEQ ID NO: 80 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 80,
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 82 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 82, or
an antibody or antigen-binding fragment of the antibody comprising a heavy chain variable region comprising the 2nd through 119th amino acid residues of SEQ ID NO: 84 and a light chain variable region comprising the 135th through 243rd amino acid residues of SEQ ID NO: 84.

[0109]

Specific examples of humanized anti-CD3 antibodies or antigen-binding fragments of the antibody of the present invention include an antibody or antigen-binding fragment of an antibody, wherein the antibody or antigen-binding fragment comprises a heavy chain variable region including an amino acid sequence represented by SEQ ID NO: 16, a linker, and a light chain variable region including an amino acid sequence represented by any one of SEQ ID NOs: 17, 20, and 23.

[0110]

In variable reagions comprised in antibodies or

antigen-binding fragments of the antibodies of the present invention, a heavy chain variable region and a light chain variable region can bind in this order, or a light chain variable region and a heavy chain variable region can bind in this order, from the amino-terminal. The variable regions can comprise a glycine residue at their amino-termini. A linker, FLAG-tag, and/or HIS-tag can bind at the end of carboxyl termini of the variable regions.

[0111] Specific preferred examples of humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include

an antibody or an antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 19,

an antibody or an antigen-binding fragment of the antibody comprising the 2nd through 243rd amino acid residues of SEQ ID NO: 22, and

an antibody or an antigen-binding fragment of the antibody comprising the 2nd through 241st amino acid residues of SEQ ID NO: 25.

[0112]

More specific preferred examples of humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody include

an antibody (Clone ID: C3E-7078) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 60

(Figure 68),
an antibody (Clone ID: C3E-7085) or an antigen-binding fragment of the antibody comprising the 1st through 241st amino acid residues of SEQ ID NO: 64 (Figure 72),
an antibody (Clone ID: C3E-7086) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 66 (Figure 74),
an antibody (Clone ID: C3E-7087) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 68 (Figure 76),
an antibody (Clone ID: C3E-7088) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 70 (Figure 78),
an antibody (Clone ID: C3E-7089) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 72 (Figure 80),
an antibody (Clone ID: C3E-7090) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 74 (Figure 82),
an antibody (Clone ID: C3E-7091) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 76

(Figure 84),
an antibody (Clone ID: C3E-7092) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 78 (Figure 86),
an antibody (Clone ID: C3E-7093) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 80 (Figure 88),
an antibody (Clone ID: C3E-7094) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 82 (Figure 90), and
an antibody (Clone ID: C3E-7095) or an antigen-binding fragment of the antibody comprising the 1st through 243rd amino acid residues of SEQ ID NO: 84 (Figure 92).

[0113]

Specific preferred examples of humanized anti-CD3 antibodies of the present invention or antigen-binding fragments of the antibody, wherein a heavy chain variable region, a linker and a light chain variable region bind in this order at the end of amino terminus, and additionally, a second linker, FLAG-tag, and HIS-tag bind at the end of carboxyl terminus of the light chain variable region,include antibodies or antigen-binding fragments of the antibody written in above-mentioned (16) which

comprise

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 22,

an amino acid sequence comprising the 2nd through 267th amino acid residues of SEQ ID NO: 25,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 60,

an amino acid sequence comprising the 2nd through 267th amino acid residues of SEQ ID NO: 64,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 66,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 68,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 70,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 72,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 74,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 76,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 78,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 80,

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 82,

or

an amino acid sequence comprising the 2nd through 269th amino acid residues of SEQ ID NO: 84.

[0114]

The antibody, etc. of the present invention may be a molecule including an antibody, etc. that comprises an amino acid sequence of a heavy chain variable region and/or an amino acid sequence of a light chain variable region which is 70%, 71%, 72%, 73%, 74%,75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% the same as the amino acid sequence of the heavy chain variable region and/or the amino acid sequence of the light chain variable region contained in the aforementioned anti-CD3 antibody of the present invention or antigen-binding fragment of the antibody, and binds to human CD3 and to cynomolgus monkey CD3.

[0115]

The antibody etc. of the present invention may be an antibody whose ability to bind to CD3 may be optimized by introducing a mutation to the aforementioned humanized anti-CD3 antibody or antigen-binding fragment of the antibody. Specific examples of the method for introducing a mutation can include random mutagenesis using error-prone PCR, site-directed amino acid mutagenesis using an NNK library, site-directed mutagenesis using structure information, and combinations thereof.

[0116]

The ADCC and CDC activities of an antibody, etc. of the present invention may be reduced by the substitution of constant regions in order to decrease the effector activity of the antibody.

[0117]

To avoid cytotoxicity in normal cells expressing human CD3, it is desirable that the antibody should have low effector activity. Effector activity is known to differ among antibody subclasses. For example, IgG4 has low ADCC and CDC activity, and IgG2 has CDC activity but low ADCC activity. Using these features, an antibody with reduced ADCC and CDC activity can be prepared by substituting the constant regions of IgG1 with the constant regions of IgG2 or IgG4. Also, an IgG1 antibody with reduced ADCC and CDC activity can be prepared by the substitution of a portion of the constant regions of IgG1 with reference to IgG2 or IgG4. For example, Marjan Hezareh et al., Journal of Virology, 75 (24): 12161-12168 (2001) show that ADCC and CDC activity is reduced by substituting the 234th and 235th leucine residues (the numbers are based on the EU index according to Kabat et al.) of IgG1 with alanine residues.

[0118]

(3-8) Antibodies that bind to same site and also bind to cynomolgus monkey CD3

An "antibody that binds to the same site" as in includes an antibody, etc. of the present invention and “binds to cynomolgus monkey CD3" also includes an antibody, etc. of the present invention. The "antibody binding to the same site" as in the case of a certain antibody means another antibody that binds to a site on an antigen molecule recognized by the antibody. If a second antibody binds to a partial peptide or a partial three-dimensional structure on an antigen molecule bound by a first antibody, the first and second antibodies are determined as binding to the same site.

[0119]

Alternatively, the first and second antibodies are determined as binding to the same site by confirming that the second antibody competes with the first antibody for binding to the antigen, i.e., the second antibody interferes with the binding of the first antibody to the antigen, even if the peptide sequence or three-dimensional structure of the specific binding site is not determined.

[0120]

When the first and second antibodies bind to the same site and the first antibody has an effect characteristic of one aspect of an antibody of the present invention, such as cytotoxic activity, the second antibody also has an exceedingly high probability of having the same activity.

[0121]

Thus, if a second anti-CD3 antibody binds to a site bound by a first anti-CD3 antibody and the second anti-CD3 antibody binds to cynomolgus monkey CD3, the first and second antibodies can be determined as binding to the same site on the CD3 protein. An antibody or an antigen-binding fragment of the antibody that binds to the same site on human CD3 as that bound by an anti-CD3 antibody of the present invention or an antigen-binding fragment of the antibody, and binds to cynomolgus monkey CD3 is also included among the antibodies, etc. of the present invention.

[0122]

Alternatively, first and second anti-CD3 antibodies can be determined as binding to the same site on the CD3 protein by confirming that the second anti-CD3 antibody competes with the first anti-CD3 antibody for binding to the CD3 protein and the second anti-CD3 antibody binds to cynomolgus monkey CD3. An antibody or an antigen-binding fragment of the antibody that competes with the anti-CD3 antibody of the present invention or antigen-binding fragment of the antibody for binding to human CD3, and binds to cynomolgus monkey CD3 is also included in the antigen, etc. of the present invention.

[0123]

The antibody binding site can be determined

using any method well known by those skilled in the art, such as immunoassay. For example, a series of peptides may be prepared by appropriately sequentially cleaving the amino acid sequence of the antigen from its carboxyl terminus or amino terminus, and then studying the reactivity of the antibody to roughly determine a recognition site. Then, shorter peptides are synthesized, and the reactivity of the antibody to these peptides can be studied to determine the binding site. The antigen fragment peptides can be prepared using a technique such as gene recombination or peptide synthesis.

[0124]

An antibody, etc. of the present invention recognizes and binds to a region constituting the three-dimensional structure of CD3, i.e., an Ig-like domain. Such a binding site (epitope) for the antibody can be determined by identifying amino acid residues on the antigen adjacent to the antibody using X-ray structural analysis.

[0125]

(3-9) Variants of anti-CD3 antibodies or antigen-binding fragments thereof

The present invention provides a variant of an antibody or antigen-binding fragment thereof. The variant of the antibody of the present invention or antigen-binding fragment thereof means an antibody of the present invention or an antigen-binding

fragment thereof provided with chemical or biological modification. The chemically variant includes, for example, a form having an amino acid skeleton conjugated with a chemical moiety, and a form having a chemically modified N-linked or O-linked carbohydrate chain. The biological variant includes, for example, a form that has undergone post-translational modification (e.g., N-linked or O-linked glycosylation, processing of an amino-terminal or carboxyl-terminal region, deamidation, isomerization of aspartic acid, or oxidation of methionine), and a form containing a methionine residue added to the amino terminus by expression using prokaryotic host cells. Such a variant is also meant to include a form labeled to permit detection or isolation of the antibody or the antigen of the present invention, for example, an enzyme-labeled form, a fluorescently labeled form, or an affinity-labeled form. Such a variant of the antibody of the present invention or antigen-binding fragment thereof is useful for improving the stability and blood retention of the original antibody of the present invention or the original antigen-binding fragment thereof, reducing antigenicity, and detecting or isolating the antibody or the antigen, etc.

[0126]

Examples of the chemical moieties contained in the chemically variants include water-soluble polymers such as polyethylene glycol, ethylene glycol/propylene glycol copolymers, carboxymethylcellulose, dextran, and polyvinyl alcohol.

[0127]

Examples of biologically variants include forms modified by enzymatic treatment or cell treatment, forms fused with other peptides, such as a tag, added by gene recombination, and forms prepared from host cells expressing an endogenous or exogenous sugar chain-modifying enzyme.

[0128]

Such a modification may be made at an arbitrary position or at a desired position in the antibody or antigen-binding fragment thereof. Alternatively, the same or different modifications may be made at one or two or more positions therein.

[0129]

In the present invention, a "variant of an antigen-binding fragment of an antibody" is also meant to include a "fragment of a variant of an antibody."

[0130]

For example, the heavy chain of an antibody produced by cultured mammalian cells is known to lack a lysine residue at the carboxy terminus (Journal of

Chromatography A, 705: 129-134 (1995)). Also, the heavy chain of such an antibody is known to lack two amino acid residues (glycine and lysine) at the carboxy terminus and instead have an amidated proline residue at the carboxy terminus (Analytical Biochemistry, 360: 75-83 (2007)). Furthermore, a N (amino)-terminal glutamine or glutamic acid residue in the heavy or light chain of an antibody is known to be modified by pyroglutamylation during preparation of the antibody, and the antibody of the present invention may have such a modification (International Publication No. WO2013/147153A1).

[0131]

Deletions in these heavy chain sequences or modifications in these heavy or light chain sequences, however, do not influence the ability of the antibody to bind to the antigen and its effector functions (complement activation, antibody dependent cytotoxic effects, etc.) very much. Thus, the present invention also encompasses antibodies that have been subjected to deletion or modification (hereinafter referred to as “deletion variants”). Examples include a deletion variant derived from a heavy chain by deletion of 1 or 2 amino acids at the carboxyl terminus, an amidated form of the deletion variant (e.g., a heavy chain having an amidated proline residue at the carboxyl-terminal site), and an antibody having a pyroglutamylated amino-terminal

residue in its heavy or light chain. However, a deletion variant at the carboxyl terminus of the antibody heavy and light chain according to the present invention is not limited to the types described above as long as the deletion variant retains at least some ability to bind to the antigen. Two or more chains (e.g., heavy chains) present in an antibody according to the present invention may be chains (e.g., heavy chains) of any type selected from a group consisting of full-length chains (e.g., heavy chains) and the deletion variants described above, as well as any combination of two or more chains (e.g., heavy chains) of any two types selected therefrom. The quantitative or molecular ratio of each deletion variant may be influenced by the type of cultured mammalian cells producing the antibody according to the present invention, and culture conditions. Examples include the deletion of one carboxyl-terminal amino acid residue each of the two heavy chains as main components of the antibody according to the present invention.
In the present invention, a "variant of an antigen-binding fragment of an antibody" is also meant to include a "fragment of a variant of an antibody."
[0132]

The antibody dependent cellular cytotoxic activity of the antibody of the present invention may be enhanced by regulating the modification

(glycosylation, defucosylation, etc.) of the sugar chain bound with the antibody. For example, International Publication Nos. WO99/54342A1, WO00/61739A1, and WO02/31140A1 make known a technique for regulating the sugar chain modification of an antibody, though this technique is not limited thereto. An antibody of the present invention and antigen-binding fragment of the antibody also include an antibody and an antigen-binding fragment of an antibody that has undergone sugar chain modification thus regulated.

[0133]

In the present invention, “deletions” and “modifications” of an antibody or antigen-binding fragment thereof, and mixture thereoffall within the scope of the “antibody or antigen-binding fragment thereof”. And, “deletions” and “modifications” of an antibody or antigen-binding fragment thereof, and mixtures thereof fall within the scope of “ an antibody or antigen-binding fragment thereof” comprised in a molecule which binds to an antigen, multispecific molecule, bispecific molecule or the like of the present invention which is disclosed in (3-5) and (3-6).

[0134]

4. Production of antibodies

(4-1) Method using hybridoma

According to one aspect of the present invention,

anti-CD3 antibody-producing cells are isolated from the spleens of animals immunized with the CD3 protein according to, for example, the method of Kohler and Milstein (Kohler and Milstein, Nature (1975) 256, p. 495-497; and Kennet, R. ed., Monoclonal Antibodies, p. 365-367, Plenum Press, N.Y. (1980)). The cells are fused with myeloma cells to establish hybridomas. Monoclonal antibodies can be obtained from cultures of these hybridomas.

[0135]

(4-1-1) Preparation of antigen

The antigen for the preparation of an anti-CD3 antibody can be obtained according to, for example, the method for preparing a native or recombinant CD3 protein (human CD3εγ single-chain antigen). Examples of antigens that may be thus prepared include the CD3 protein, CD3 protein fragments, and derivatives thereof further comprising an arbitrary amino acid sequence or carrier added (hereinafter, collectively referred to as "CD3").

[0136]

The native CD3 can be purified and isolated from, for example, human tissue-derived cells or cultures of the cells. The recombinant human CD3εγ single-chain antigen can be prepared by transfecting host cells with a gene comprising a nucleotide sequence encoding the amino acid sequence of the human CD3εγ single-chain antigen, and recovering the antigen from

cultures of the cells. CD3 obtained by cell-free protein synthesis in an *in vitro* translation system from a gene comprising a nucleotide sequence encoding the amino acid sequence of the CD3 antigen is also included among "CD3 antigens" of the present invention.

[0137]

(4-1-2) Production of anti-CD3 monoclonal antibodies

A monoclonal antibody is typically produced through the following steps:

(a) preparing an antigen,

(b) preparing antibody-producing cells,

(c) preparing myeloma cells (hereinafter, referred to as "myelomas"),

(d) fusing the antibody-producing cells with the myelomas,

(e) screening for a hybridoma group producing the antibody of interest, and

(f) obtaining single cell clones (cloning).

[0138]

This production method further involves (g) a step of culturing the hybridomas, a step of raising hybridoma-transplanted animals, etc., and (h) a step of assaying or determining the biological activity of the monoclonal antibody, etc., if necessary.

[0139]

This method for preparing monoclonal antibodies

will now be described in detail with reference to these steps. However, the method for preparing the antibody is not limited to these steps. For example, antibody-producing cells other than spleen cells and myelomas may be used.

(a) Step of preparing antigens

A CD3 protein of the present invention can be prepared by purification or isolation from animal tissues (including body fluids), cells derived from the tissues, or cultures of the cells, gene recombination, cell-free protein synthesis, chemical synthesis, etc.

(b) Step of preparing antibody-producing cells

The antigen obtained in step (a) is mixed with an adjuvant such as a complete or incomplete Freund's adjuvant or potassium aluminum sulfate, and laboratory animals are immunized with the resulting immunogen. Any laboratory animal used in a hybridoma preparation method known in the art can be used without limitations. For example, mice, rats, goats, sheep, cattle, and horses can be used. From the viewpoint of readily available myeloma cells to be fused with isolated antibody-producing cells, etc., the animals to be immunized are preferably mice or rats.

[0140]

The strain of mice or rats actually used is not particularly limited. In the case of mice, for

example, A, AKR, BALB/c, BALB/cAnNCrj, BDP, BA, CE, C3H, 57BL, C57BL, C57L, DBA, FL, HTH, HT1, LP, NZB, NZW, RF, R III, SJL, SWR, WB, or 129 can be used. In the case of rats, for example, Wistar, Low, Lewis, Sprague-Dawley, ACI, BN, or Fischer can be used.

[0141]

These mice and rats are available from laboratory animal breeders or distributors, for example, CLEA Japan, Inc. or Charles River Laboratories Japan, Inc.

[0142]

Of those mice and rats, a BALB/c mouse strain or Wistar and Low rat strains are particularly preferred as animals to be immunized in consideration of fusion compatibility with the myeloma cells described later.

[0143]

Also, in consideration of the homology between human and mouse antigens, mice whose biological mechanism to remove autoantibodies has been reduced, i.e., autoimmune disease mice, are also preferably used.

[0144]

In this context, these mice or rats are preferably 5 to 12 weeks old, and more preferably 6 to 8 weeks old, at the time of immunization.

The animals can be immunized with the CD3 protein using, for example, the method of Weir, D. M., Handbook of Experimental Immunology Vol. I. II. III., Blackwell Scientific Publications, Oxford

(1987), or Kabat, E. A. and Mayer, M. M., Experimental Immunochemistry, Charles C Thomas Publisher Spigfield, Illinois (1964).

[0146]

Examples of methods for determining antibody titers can include, but are not limited to, immunoassays such as RIA and ELISA.

[0147]

Antibody-producing cells derived from spleen cells or lymphocytes separated from the immunized animals, can be prepared according to a method known in the art, for example, Kohler et al., Nature (1975) 256, 495; Kohler et al., Eur. J. Immnol. (1977) 6, 511; Milstein et al., Nature (1977), 266, 550; or Walsh, Nature (1977) 266, 495.

[0148]

In the case of spleen cells, a general method can be adopted, which involves chopping the spleens, filtering cells through a stainless-steel mesh, and then floating the resulting cells in an Eagle's minimum essential medium (MEM) to separate the antibody-producing cells.

(c) Step of preparing myelomas

The myeloma cells used in cell fusion are not particularly limited and can be selected for use from cell lines known in the art. For example, a hypoxanthine-guanine phosphoribosyl transferase (HGPRT)-deficient line, i.e., mouse-derived X63-Ag8

(X63), NS1-ANS/1 (NS1), P3X63-Ag8.Ul (P3Ul), X63-Ag8.653 (X63.653), SP2/0-Ag14 (SP2/0), MPC11-45.6TG1.7 (45.6TG), FO, S149/5XXO, or BU.1, rat-derived 210.RSY3.Ag.1.2.3 (Y3), or human-derived U266AR (SKO-007), GM1500-GTG-A12 (GM1500), UC729-6, LICR-LOW-HMy2 (HMy2), or 8226AR/NIP4-1 (NP41), whose screening procedures have already been established, are preferably used in consideration of convenience in the selection of hybridomas from fusion cells. These HGPRT-deficient lines are available from, for example, the American Type Culture Collection (ATCC). [0149]

These cell lines are subcultured in an appropriate medium, for example, an 8-azaguanine medium [RPMI-1640 medium supplemented with glutamine, 2-mercaptoethanol, gentamicin, and fetal bovine serum (hereinafter, referred to as "FCS") and further supplemented with 8-azaguanine], an Iscove's modified Dulbecco's medium (hereinafter, referred to as "IMDM"), or a Dulbecco's modified Eagle medium (hereinafter, referred to as "DMEM") and subcultured in a normal medium [e.g., ASF104 medium (manufactured by Ajinomoto Co., Inc.) containing 10% FCS] for 3 to 4 days before cell fusion to ensure that the number of cells is equal to or greater than 2×10^7 cells on the day of cell fusion.

(d) Step of fusing antibody-producing cells with myeloma cells

The antibody-producing cells can be fused with the myeloma cells under conditions that prevent cell viability from being excessively reduced, according to any method known in the art (e.g., Weir, D.M., Handbook of Experimental Immunology Vol. I. II. III., Blackwell Scientific Publications, Oxford (1987), Kabat, E. A. and Mayer, M. M., Experimental Immunochemistry, Charles C Thomas Publisher Spigfield, Illinois (1964)). For example, a chemical method which involves mixing antibody-producing cells with myeloma cells in a high-concentration solution of a polymer such as polyethylene glycol, or a physical method using electric stimulation can be used.

(e) Step of screening for the hybridoma group producing the antibody of interest

The method used to select hybridomas obtained by cell fusion is not particularly limited, but a hypoxanthine-aminopterin-thymidine (HAT) selection method (Kohler et al., Nature (1975) 256, 495; Milstein et al., Nature (1977) 266, 550) is typically used. This method is effective for obtaining hybridomas using an HGPRT-deficient myeloma cell line, which cannot survive in the presence of aminopterin. Specifically, unfused cells and hybridomas can be cultured in a HAT medium to allow hybridomas resistant to aminopterin to selectively live and grow.

(f) Step of obtaining single-cell clones (cloning)

The hybridomas can be cloned using any method known in the art, for example, a methylcellulose, soft agarose, or limiting dilution method (e.g., Barbara, B.M. and Stanley, M.S.: Selected Methods in Cellular Immunology, W.H. Freeman and Company, San Francisco (1980)). The limiting dilution method is preferred.

(g) Step of culturing hybridomas and step of raising hybridoma-transplanted animals

The selected hybridomas can be cultured to produce monoclonal antibodies. Preferably, the desired hybridomas are cloned and then subjected to antibody production.

[0150]

The monoclonal antibody produced by such a hybridoma can be recovered from cultures of the hybridoma. Also, a recombinant antibody can be recovered from cultures of cells transfected with the monoclonal antibody gene. Alternatively, the hybridoma may be injected intraperitoneally into mice of the same strain (e.g., BALB/cAnNCrj described above) or Nu/Nu mice and allowed to grow. Then, the monoclonal antibodies can be recovered from their ascites.

(h) Step of assaying or determining biological activity of monoclonal antibodies

Various biological tests can be selected and applied depending on the purpose.

[0151]

(4-2) Cell immunization method

Cells expressing native CD3 or cells expressing recombinant CD3 or its fragment can be used as immunogens to prepare an anti-CD3 antibody using the hybridoma method described above.

[0152]

Examples of the cells expressing native CD3 include human thymus cells and T lymphocytes. These CD3-expressing cells are used in an amount of 1×10^5 to 1×10^9 cells, preferably 1×10^6 to 1×10^8 cells, more preferably 0.5 to 2×10^7 cells, and even more preferably 1×10^7 cells, per immunization shot. The number of cells used for immunization can be changed depending on the expression level of CD3. The immunogens are generally administered intraperitoneally but may be administered by an intradermal route. The hybridomas can be prepared by the application of the method described in section (4-1-2).

[0153]

(4-3) DNA immunization method

An anti-CD3 antibody of the present invention can also be obtained by use of a DNA immunization method. This method involves transfecting an individual animal, e.g., mouse or rat, with an

antigen expression plasmid and expressing the antigen in the individual to thereby induce immunity against the antigen. Examples of the transfection approach include a method of directly injecting the plasmid into the muscle, a method of injecting a transfection reagent such as a liposome or polyethylenimine into a vein, an approach using a viral vector, an approach of injecting plasmid-affixed gold particles using a gene gun, and a hydrodynamic method of rapidly injecting a large amount of plasmid solution into a vein.

[0154]

An actual example of a rat anti-human CD3 antibody thus obtained is C3-147. The amino acid sequence of the light chain variable region of C3-147 is shown in SEQ ID NO: 9 of the Sequence Listing (Figure 17). The amino acid sequence of the heavy chain variable region of C3-147 is shown in SEQ ID NO: 7 of the Sequence Listing (Figure 15).

[0155]

(4-4) Gene recombination

In order to prepare an antibody of the present invention, a nucleotide (heavy chain nucleotide) comprising a nucleotide sequence encoding the amino acid sequence of its heavy chain and a nucleotide (light chain nucleotide) comprising a nucleotide sequence encoding the amino acid sequence of its light chain, or a vector having an insert of the

heavy chain nucleotide and a vector having an insert of the light chain nucleotide, is introduced into host cells, the cells are cultured, and the antibody is recovered from the culture. The heavy chain nucleotide and the light chain nucleotide may be inserted in one vector.

[0156]

Prokaryotic or eukaryotic cells can be used as the host cells. When host eukaryotic cells are used, animal cells, plant cells, or eukaryotic microbes can be used.

[0157]

Examples of the animal cells include mammal-derived cells, i.e., human embryonic kidney cells HEK293F cells (Subedi GP et al., J Vis Exp. (2015) 106), monkey kidney-derived COS cells (Gluzman, Y. Cell (1981), 23, 175-182, ATCC CRL-1650), mouse fibroblast NIH3T3 (ATCC No. CRL-1658), Chinese hamster ovary cells (CHO cells, ATCC CCL-61), dihydrofolate reductase-deficient lines thereof (CHOdhfr-; Urlaub, G. and Chasin, L.A. PNAS (1980), 77, 4126-4220), cells derived from birds such as chickens, and cells derived from insects.

[0158]

Also, cells modified to enhance the biological activities of antibodies by the modification of sugar chain structures can be used as the hosts. For example, CHO cells modified so that the proportion

of sugar chains with fucose unbound with N-acetylglucosamine at their reducing ends is 20% or more among complex-type N-glycoside-linked sugar chains to be bound to the Fc region of the antibody, may be used to prepare an antibody having enhanced ADCC activity or CDC activity (International Publication No. WO02/31140A1).

[0159]

Examples of eukaryotic microbes include yeasts. Examples of the prokaryotic cells include *E. coli* and *Bacillus subtilis*.

[0160]

A signal peptide for the secretion of an antibody of the present invention (monoclonal antibodies derived from each animal, rat antibodies, mouse antibodies, chimeric antibodies, humanized antibodies, human antibodies, etc.) is not limited to the secretory signal of an antibody of the same species, the same type, or the same subtype as the antibody of the present invention or to the antibody of the present invention's own secretory signal. Any secretory signal of an antibody of a different type or subtype or any secretory signal of a protein derived from a different eukaryotic species or prokaryotic species can be selected and used.

[0161]

A secreted antibody, etc. containing the signal peptide is also encompassed by the antibody, etc. of

the present invention or the molecule of the present invention.

[0162]

(4-5) Methods for designing and preparing humanized antibodies

Examples of humanized antibodies include, but are not limited to, human-derived antibodies having CDRs replaced with the CDRs of non-human animal antibodies (see Nature (1986), 321, p. 522-525), human antibodies grafted to CDR sequences and some amino acid residues of framework regions by CDR grafting (see WO90/07861A1 and US6972323B2), and antibodies having one or more human antibody amino acid replaced by one or more non-human animal antibody-derived amino acid in any of these humanized antibodies.

[0163]

(4-6) Method for preparing human antibodies

Other examples of antibodies of the present invention include human antibodies. Human anti-CD3 antibody means an anti-CD3 antibody consisting of the amino acid sequence of a human-derived antibody. A human anti-CD3 antibody can be obtained by a method using human antibody-producing mice carrying human genomic DNA fragments comprising human antibody heavy and light chain genes (see e.g., Tomizuka, K. et al., Nature Genetics (1997) 16, 133-143; Kuroiwa, Y. et. al., Nuc. Acids Res. (1998) 26, 3447-3448; Yoshida,

H. et. al., Animal Cell Technology: Basic and Applied Aspects vol. 10, 69-73 (Kitagawa, Y., Matuda, T. and Iijima, S. eds.), Kluwer Academic Publishers, 1999.; Tomizuka, K. et.al., Proc. Natl. Acad. Sci. USA (2000) 97, 722-727).

[0164]

Specifically, human antibody-producing animals can be prepared by disrupting the endogenous immunoglobulin heavy and light chain gene loci of non-human mammals and introducing human immunoglobulin heavy and light chain gene loci via, for example, yeast artificial chromosome (YAC) vectors. Alternatively, eukaryotic cells may be transformed with cDNAs encoding the heavy and light chains, respectively, of such a human antibody, preferably with vectors comprising the cDNAs, by a gene recombination technique. The transformed cells producing a recombinant human monoclonal antibody can be cultured. This antibody can be obtained from the culture supernatant.

[0165]

In this context, for example, eukaryotic cells, preferably mammalian cells such as HEK293F cells or CHO cells, can be used as the hosts.

[0166]

Also, a method for obtaining a phage display-derived human antibody selected from a human antibody library is also known. For example, a phage display

method can be used which involves allowing the variable regions of a human antibody to be expressed as scFv on a phage surface and selecting the phage binding to the antigen. A phage selected on the basis of its ability to bind to the antigen can be subjected to gene analysis to determine DNA sequences encoding the variable regions of the human antibody binding to the antigen. If the DNA sequence of scFv binding to the antigen is determined, an expression vector with this sequence can be prepared and introduced to a suitable host to allow them to express the human antibody (WO92/01047A1, WO92/20791 A1, WO93/06213 A1, WO93/11236 A1, WO93/19172 A1, WO95/01438 A1, WO95/15388 A1, Annu. Rev. Immunol (1994) 12, 433-455).

[0167]

(4-7) Method for preparing antigen-binding fragments of antibodies

The method for preparing scFv is well known in the art (see e.g., US. Patent Nos. 4,946,778, 5,260,203, 5,091,513, and 5,455,030). In this scFv, a heavy chain variable region and a light chain variable region are linked via a linker that prevents them from forming a conjugate, preferably a polypeptide linker (Huston, J.S. et al., PNAS (1988), 85, 5879-5883). The heavy chain variable region and the light chain variable region in scFv may be

derived from the same antibody or may be derived from different antibodies.

[0168]

For example, an arbitrary single chain peptide consisting of 5 to 30 residues is used as the polypeptide linker that links these variable regions.

[0169]

In order to obtain scFv-encoding DNA of the sequences of DNA encoding the heavy chain or heavy chain variable region of the antibody and DNA encoding the light chain or light chain variable region thereof, each DNA portion encoding the entire or desired amino acid sequence is used as a template and amplified by PCR using a primer pair flanking both ends of the template. Subsequently, DNA encoding the polypeptide linker moiety is further amplified in combination with a primer pair flanking both ends of the DNA so that the resulting fragment can be linked at its ends to the heavy and light chain DNAs. Alternatively, the DNA encoding the whole scFv region may be obtained by net synthesis.

[0170]

The scFv-encoding DNA can be used to prepare, according to a routine method, an expression vector containing the DNA and host cells transformed with the expression vector. In addition, the host cells can be cultured, and the scFv can be recovered from the cultures using a routine method.

[0171]

Also in order to obtain any other antigen-binding fragment of the antibody, a gene encoding the antigen-binding fragment is obtained according to the method described above and introduced to cells. The antigen-binding fragment of interest can be recovered from cultures of the cells.

[0172]

The antibody, etc. of the present invention may be multimerized to enhance its affinity for the antigen. In this case, antibodies of the same type may be multimerized, or a plurality of antibodies recognizing a plurality of epitopes, respectively, of the same antigen may be multimerized. Examples of methods for multimerizing these antibodies can include the binding of two scFvs to an IgG CH3 domain, the binding of these to streptavidin, and the introduction of a helix-turn-helix motif.

[0173]

The antibody, etc. of the present invention may be a mixture of plural types of anti-CD3 antibodies differing in amino acid sequence, i.e., a polyclonal antibody. Examples of the polyclonal antibody can include a mixture of multiple types of antibodies with CDR sets differing in whole or in part. Such a polyclonal antibody can be recovered from cultures of mixed-cultured different antibody-producing cells (WO2004/061104A1). Alternatively, separately

prepared antibodies may be mixed. Antiserum, which is one aspect of the polyclonal antibody, can be prepared by immunizing animals with the desired antigen and recovering serum from the animals according to a standard method.

[0174]

Antibodies conjugated with various molecules such as polyethylene glycol (PEG) can also be used as variants of the antibody.

[0175]

The antibody, etc. of the present invention may be any conjugate formed by these antibodies with other molecules via linkers (immunoconjugates). An antibody-drug complex in which the antibody is conjugated with a radioactive material or a compound (drug) having pharmacological action can include ADC (antibody-drug conjugate) (Methods Mol Biol. (2013) 1045: 1-27).

[0176]

The antibody, etc. of the present invention may further be any of antibody connected to other functional polypeptides. An example of such an antibody-peptide complex is a complex of the antibody and an albumin-binding polypeptide (Protein Eng Des Sel. (2012) (2): 81-8).

[0177]

(4-8) Purification of the antibody and antigen-binding fragment of the antibody

The resulting antibody and antigen-binding fragment of the antibody can be purified until homogeneous so as not to contain materials other than the antibody, etc. Common protein separation and purification methods can be used for the separation and purification of the antibody and antigen-binding fragment of the antibody.

[0178]

The antibody can be separated and purified by appropriately selected or combined approaches, for example, chromatography columns, filters, ultrafiltration, salting out, dialysis, preparative polyacrylamide gel electrophoresis, and isoelectric focusing, though the separation and purification method is not limited.

[0179]

The separation and purification method is preferably performed, for example, by preparing an expression vector using a DNA sequence encoding a His tag or a FLAG tag added to the carboxyl terminus of an antibody variable region, transforming cells with this vector, then culturing the cells to express the antibody and antigen-binding fragment of the antibody, and extracting the culture supernatant after the completion of the culture, followed by purification using metal (e.g., Ni or Co) affinity chromatography, anti-FLAG tag antibody columns, gel filtration, or ion-exchange chromatography.

[0180]

The expressed antibody and antigen-binding fragments of the antibody containing an amino acid sequence encoding a tag such as a His tag or a FLAG tag is also encompassed by the antigen, etc. of the present invention or the molecule of the present invention.

[0181]

(4-9) Multispecific molecules and bispecific molecules

Examples of methods for preparing the bispecific molecule and the multispecific molecule of the present invention include a method which involves introducing expression plasmids to host cells to cause transient expression, a method which involves introducing plasmids to host cells and then selecting a stably expressing cell line by drug selection to cause permanent expression, a method which involves cell-free synthesis, and a method which involves preparing antibodies or antigen-binding fragments by any of the methods described above, and then chemically linking these antibodies or fragments using a synthetic peptide linker.

[0182]

As for bispecific molecule preparation using antibody variable regions, examples include a method which involves connecting two single-chain antibodies (scFvs) via a peptide linker (tandem scFv),

a method which involves cross-pairing domains of two antibodies differing in specificity, and forming a dimer by a noncovalent bond (diabody), a method which involves cross-pairing domains of two antibodies differing in specificity and forming a single chain (single-chain diabody), and a method which involves preparing single-chain diabodies and then forming a dimer by a noncovalent bond (TandAb, US7129330B2).

[0183]

The present invention also provides a gene encoding the antibody of the present invention or antigen-binding fragment of the antibody, or a variant of the antigen, etc., a recombinant vector having an insert of the gene, a cell transfected with the gene or vector, and a cell producing the antibody of the present invention.

[0184]

5. Pharmaceutical compositions

The present invention provides a pharmaceutical composition comprising the anti-CD3 antibody or antigen-binding fragment thereof, or the variant of the antibody or antigen-binding fragment, and/or the molecule of the present invention comprising any of them, for example, the multispecific molecule.

[0185]

In the present invention, the treatment and/or prevention of a disease includes, but is not limited to, the prevention of the onset of the disease, the

suppression or inhibition of advancement or progress thereof, the alleviation of one or two or more symptoms exhibited by an individual affected with the disease, the suppression or remission of advancement or progress thereof, and the treatment or prevention of a secondary disease, etc. In the case of the molecule, examples of diseases include cancers.

[0186]

The pharmaceutical composition of the present invention can comprise a therapeutically or prophylactically effective amount of the anti-CD3 antibody or antigen-binding fragment of the antibody and a pharmaceutically acceptable diluent, vehicle, solubilizer, emulsifier, preservative, and/or additive.

[0187]

"Therapeutically or prophylactically effective amount" means an amount that has therapeutic or prophylactic effects on a particular disease by means of a particular dosage form and administration route.

[0188]

The pharmaceutical composition of the present invention may comprise materials for changing, maintaining, or retaining pH, osmotic pressure, viscosity, transparency, color, tonicity, sterility, or the stability, solubility, sustained release, absorbability, permeability, dosage form, strength, properties, shape, etc., of the composition or the

antibody comprised therein (hereinafter, referred to as "pharmaceutical materials"). The pharmaceutical materials are not particularly limited as long as the materials are pharmacologically acceptable. For example, non-toxic or low toxicity is a property preferably possessed by these pharmaceutical materials.

[0189]

Examples of pharmaceutical materials include, but are not limited to, the following: amino acids such as glycine, alanine, glutamine, asparagine, histidine, arginine, and lysine; antimicrobial agents; antioxidants such as ascorbic acid, sodium sulfate, and sodium bisulfite; buffers such as phosphate, citrate, or borate buffers, sodium bicarbonate, and Tris-HCl solutions; fillers such as mannitol and glycine; chelating agents such as ethylenediaminetetraacetic acid (EDTA); complexing agents such as caffeine, polyvinylpyrrolidine, β-cyclodextrin, and hydroxypropyl-β-cyclodextrin; bulking agents such as glucose, mannose, and dextrin; hydrocarbons such as monosaccharides, disaccharides, glucose, mannose, and dextrin; coloring agents; corrigents; diluents; emulsifiers; hydrophilic polymers such as polyvinylpyrrolidine; low molecular weight polypeptides; salt-forming counterions; antiseptics such as benzalkonium chloride, benzoic acid, salicylic acid, thimerosal, phenethyl alcohol,

methylparaben, propylparaben, chlorhexidine, sorbic acid, and hydrogen peroxide; solvents such as glycerin, propylene glycol, and polyethylene glycol; sugar alcohols such as mannitol and sorbitol; suspending agents; surfactants such as PEG, sorbitan ester, polysorbates such as polysorbate 20 and polysorbate 80, triton, tromethamine, lecithin, and cholesterol; stability enhancers such as sucrose and sorbitol; elasticity enhancers such as sodium chloride, potassium chloride, mannitol, and sorbitol; transport agents; diluents; excipients; and pharmaceutical additives.

[0190]

The amount of these pharmaceutical materials added is 0.001 to 1000 times, preferably 0.01 to 100 times, and more preferably 0.1 to 10 times the weight of the anti-CD3 antibody or antigen-binding fragment thereof, or the variant of the antibody or antigen-binding fragment, or a molecule of the present invention such as a multispecific molecule.

[0191]

An immunoliposome comprising an anti-CD3 antibody of the present invention or an antigen-binding fragment thereof, or a variant of the antibody or antigen-binding fragment, or a molecule of the present invention such as a multispecific molecule, encapsulated in a liposome, or a pharmaceutical composition comprising a modified

antibody form comprising the antibody conjugated with a liposome (U.S. Patent No. 6214388, etc.) are also included among the pharmaceutical compositions of the present invention.

[0192]

The excipients or carriers are not particularly limited as long as they are liquid or solid materials usually used in injectable water, saline, artificial cerebrospinal fluids, and other preparations for oral or parenteral administration. Examples of saline can include neutral saline and serum albumin-containing saline.

[0193]

Examples of buffers can include a Tris buffer adjusted to bring the final pH of the pharmaceutical composition to 7.0 to 8.5, an acetate buffer adjusted to bring the final pH to 4.0 to 5.5, a citrate buffer adjusted to bring the final pH to 5.0 to 8.0, and a histidine buffer adjusted to bring the final pH to 5.0 to 8.0.

[0194]

A pharmaceutical composition of the present invention is a solid, a liquid, or a suspension. Another example of a pharmaceutical composition of the present invention is a freeze-dried preparation. Freeze-dried preparations can be formed using an excipient such as sucrose.

[0195]

The administration route for a pharmaceutical composition of the present invention may be any of enteral administration, local administration, or parenteral administration, and is preferably selected depending on the targeted disease. Specific examples include intravenous administration, intra-arterial administration, intramuscular administration, intradermal administration, hypodermic administration, intraperitoneal administration, transdermal administration, intraosseous administration, and intraarticular administration.

[0196]

The composition of the pharmaceutical composition can be determined on the basis of the administration method, the binding affinity of the antibody for the CD3 protein, etc.

[0197]

The dose of an anti-CD3 antibody of the present invention or antigen-binding fragment thereof, or a variant of the antibody or antigen-binding fragment, or a molecule of the present invention such as a multispecific molecule can be determined on the basis of the species of the individual, the type of disease, symptoms, sex, age, pre-existing conditions, the binding affinity of the antibody for the CD3 protein or its biological activity, and other factors. A dose of usually 0.01 to 1000 mg/kg, preferably 0.1 to 100

mg/kg, can be administered once daily for 180 days or twice or three or more times daily.

Examples of forms for the pharmaceutical composition include injections (including freeze-dried preparations and drops), suppositories, transnasal absorption preparations, transdermal absorption preparations, sublingual formulations, capsules, tablets, ointments, granules, aerosols, pills, powders, suspensions, emulsions, eye drops, and biological implant formulations.

[0198]

An anti-CD3 antibody of the present invention or antigen-binding fragment thereof, or a variant of the antibody or antigen-binding fragment, and/or a molecule of the present invention comprising any of them such as multispecific molecule (hereinafter, referred to as the "anti-CD3 antibody, etc.") can be used in combination with another drug. The anti-CD3 antibody, etc. or the pharmaceutical composition comprising the anti-CD3 antibody, etc. as an active ingredient can be administered concurrently with or separately from the other drug, i.e., a pharmaceutical composition comprising a drug other than the anti-CD3 antibody, etc. as an active ingredient. For example, the pharmaceutical composition comprising the anti-CD3 antibody, etc. as an active ingredient may be administered after administration of the other drug, or the other drug

may be administered after administration of the pharmaceutical composition comprising the anti-CD3 antibody, etc. as an active ingredient. Alternatively, the pharmaceutical composition comprising the anti-CD3 antibody, etc. as an active ingredient and the other drug may be administered concurrently. In the present invention, a case in which the anti-CD3 antibody, etc. and the other drug are both contained as active ingredients in a single pharmaceutical composition and a case in which these active ingredients are separately contained in a plurality of pharmaceutical compositions are both included in the scope of the "pharmaceutical composition comprising the anti-CD3 antibody, etc. and another drug." In the present invention, the "pharmaceutical composition" has the same meaning as a "pharmaceutical composition in which the anti-CD3 antibody, etc. is to be administered in combination with another drug."

[0199]

In the present invention, the phrase "administered in combination" used for the anti-CD3 antibody, etc. and the other drug means that the anti-CD3 antibody, etc. and the other drug are introduced to the body of a recipient within a certain period. A single preparation containing the anti-CD3 antibody, etc. and the other drug may be administered, or the anti-CD3 antibody, etc. and the

other drug may be separately formulated and administered as separate preparations. In the case of separate preparations, the timing of administration is not particularly limited, and the preparations may be administered concurrently or may be administered at different times or on different days in an alternating manner. In a case in which the anti-CD3 antibody, etc. and the other drug are separately administered at different times or on different days, the order of administration is not particularly limited. Since separate preparations are usually administered according to their respective administration methods, the frequency of administration may be the same or different. Further, the separate preparations may be administered by the same administration method (administration route) or may be administered by different administration methods (administration routes). It is not necessary that the anti-CD3 antibody, etc. and the other drug be present in the body concurrently, and it is sufficient that the anti-CD3 antibody, etc. and the other drug are introduced to the body for a certain period of time (e.g., for 1 month, preferably for 1 week, more preferably for several days, even more preferably for 1 day). Alternatively, when one of the active ingredients is administered, the other active ingredient may have already disappeared from the body.

[0200]

Examples of dosage forms for the "pharmaceutical composition in which the anti-CD3 antibody, etc. is to be administered in combination with the other drug" can include 1) the administration of a single preparation containing the anti-CD3 antibody, etc. and the other drug, 2) the concurrent administration through the same administration route of two preparations obtained by separately formulating the anti-CD3 antibody, etc. and the other drug, 3) the administration in an alternating manner through the same administration route of two preparations obtained by separately formulating the anti-CD3 antibody, etc. and the other drug, 4) the concurrent administration through different administration routes of two preparations obtained by separately formulating the anti-CD3 antibody, etc. and the other drug, and 5) the administration in an alternating manner through different administration routes of two preparations obtained by separately formulating the anti-CD3 antibody, etc. and the other drug. The dose, dosing interval, dosage form, preparation, etc., of the "pharmaceutical composition in which the anti-CD3 antibody, etc. is to be administered in combination with the other drug" depends on the pharmaceutical composition comprising the anti-CD3 antibody, etc., but are not limited.

[0201]

A pharmaceutical composition formulated in two different preparations may be in the form of a kit containing these preparations.

[0202]

In the present invention, the "combination" of the anti-CD3 antibody, etc. and the other drug means that the anti-CD3 antibody, etc. and the other drug are "administered in combination."

[0203]

An additional drug can also be used in the combination or the pharmaceutical composition of the present invention.

[0204]

The present invention provides a method for treating or preventing CD3-related diseases, use of the antibody of the present invention for preparing a pharmaceutical composition for treatment or prevention of the diseases, and use of the antibody of the present invention for treating or preventing the diseases. The present invention also encompasses a kit for treatment or prevention comprising the antibody of the present invention.

[Examples]

[0205]

The present invention will now be described in more detail with reference to examples. However, the present invention is not limited to these examples.

Procedures related to gene manipulation in the examples below were performed according to the methods described in "Molecular Cloning" (Sambrook, J., Fritsch, E.F. and Maniatis, T., Cold Spring Harbor Laboratory Press, 1989), or using commercially available reagents or kits according to the instruction manuals, unless otherwise specified.

[0206]

(Example 1) Preparation of rat anti-human CD3 antibody

1)-1 Construction of human CD3εδ expression vector

A control vector pcDNA3.1-DEST engineered as a destination vector was prepared using the Gateway Vector Conversion System (Thermo Fisher Scientific Inc.). A cDNA encoding the human CD3ε protein (NCBI Reference Sequence: NP_000724.1) shown in Figure 1 (SEQ ID NO: 1) was purchased from Sino Biological Inc. and cloned in the pcDNA3.1-DEST vector using Gateway LR Clonase Enzyme mix (Thermo Fisher Scientific Inc.) to construct hCD3ε-pcDNA3.1. A cDNA encoding the human CD3δ protein (NP_000723.1) shown in Figure 2 (SEQ ID NO: 2) was amplified by PCR using a human T cell-derived cDNA as a template according to a method known to those skilled in the art, and cloned in pcDNA3.1(+) (Thermo Fisher Scientific Inc.) to construct an expression vector hCD3δ-pcDNA3.1. For the large-scale preparation of each expression vector,

Endofree Plasmid Giga Kit (Qiagen N.V.) was used.

[0207]

1)-2 Immunization

For immunization, WKY/Izm female rats (Japan SLC, Inc.) were used. First, both lower thighs of each rat were pretreated with hyaluronidase (Sigma-Aldrich Corp.). Then, the hCD3ε-pcDNA3.1 and hCD3δ-pcDNA3.1 expression vectors prepared in Example 1)-1 were intramuscularly injected at these sites. Subsequently, the *in vivo* electroporation of these sites was carried out using ECM830 (BTX) and a two-needle electrode. The same *in vivo* electroporation as above was repeated approximate once every two weeks. Then, the lymph nodes or the spleens were harvested from the rats and used in hybridoma preparation.

[0208]

1)-3 Hybridoma preparation

The lymph node cells or the spleen cells were electrically fused with mouse myeloma SP2/0-ag14 cells (ATCC, No. CRL-1 581) using LF301 Cell Fusion Unit (BEX Co., Ltd.). The fused cells were diluted with ClonaCell-HY Selection Medium D (StemCell Technologies Inc.) and cultured. Hybridoma colonies were recovered to prepare monoclonal hybridomas. Each hybridoma colony thus recovered was cultured using ClonaCell-HY Selection Medium E (StemCell Technologies Inc.), and the resulting hybridoma

culture supernatant was used to screen for an anti-human CD3 antibody-producing hybridoma.

[0209]

1)-4 Antibody screening by Cell-ELISA

1)-4-1 Preparation of antigen gene-expressing cell for Cell-ELISA

HEK293α cells (stably expression HEK293-derived cell line expressing integrin αv and integrin β3) were adjusted to 7.5 × 10^5 cells/mL in a DMEM medium containing 10% FBS. hCD3ε-pcDNA3.1 and hCD3δ-pcDNA3.1, or a control pcDNA3.1-DEST was transfected thereto according to transfection procedures using Lipofectamine 2000 (Thermo Fisher Scientific Inc.). The resulting cells were dispensed in an amount of 100 μL/well to a 96-well plate (Corning Inc.) and cultured overnight at 37°C under 5% CO_2 conditions in a DMEM medium containing 10% FBS. The resulting transfected cells were used in the attached state in Cell-ELISA.

[0210]

1)-4-2 Cell-ELISA

After removal of the culture supernatant from the expression vector-transfected HEK293α cells prepared in Example 1)-4-1, each hybridoma culture supernatant was added to the hCD3ε-pcDNA3.1- and hCD3δ-pcDNA3.1-, or pcDNA3.1-DEST-transfected HEK293α cells, and the plate was left standing at 4°C for 1 hour. The cells in the wells were washed once

with PBS containing 5% FBS. Then, anti-Rat IgG and HRP-Linked Whole Ab Goat (GE Healthcare Bio-Sciences Corp.) diluted 500-fold with PBS containing 5% FBS was added, and the plate was left standing at 4°C for 1 hour. The cells in the wells were washed twice with PBS containing 5% FBS. Then, an OPD chromogenic solution (OPD solution (o-phenylenediamine dihydrochloride (Wako Pure Chemicals Industries, Ltd.) and H_2O_2 dissolved at concentrations of 0.4 mg/mL and 0.6% (v/v), respectively, in 0.05 M trisodium citrate and 0.1 M disodium hydrogen phosphate dodecahydrate, pH 4.5)) were added at a concentration of 100 μL/well. Color reaction was performed with occasional stirring and stopped by the addition of 1 M HCl at a concentration of 100 μL/well. Then, the absorbance was measured at 490 nm using a plate reader (ENVISION; PerkinElmer, Inc.). In order to select a hybridoma producing an antibody binding to human CD3 expressed on cell membrane surface, hybridomas that yielded a culture supernatant exhibiting higher absorbance for the hCD3ε-pcDNA3.1 and hCD3δ-pcDNA3.1 expression vector-transfected HEK293α cells compared with the control pcDNA3.1-DEST-transfected HEK293 cells were selected as anti-human CD3 antibody production-positive hybridomas.

[0211]

1)-5 Antibody screening based on activation of human T cells

The anti-CD3 antibody obtained from hybridoma was evaluated for its activation of T cells with the detection of a CD69 activation marker as an index. Human T cell line Jurkat cells (ATCC, No. TIB-152) were adjusted to a concentration of 5×10^6 cells/mL in an RPMI1640 medium containing FBS and added at a concentration of 100 μL/well to a 96-well plate. After removal of the supernatant by centrifugation, the culture supernatant of each anti-human CD3 antibody production-positive hybridoma selected by Cell-ELISA in Example 1)-4 or a rat IgG isotype control antibody (R&D Systems, Inc.) was added at a final concentration of 5 μg/mL to the Jurkat cells, and the plate was left standing at 37°C for 30 minutes. Then, the cross-linker Goat Anti-rat IgG Fcγ Fragment specific (Jackson ImmunoResearch Laboratories, Inc.) was added at a final concentration of 10 μg/well, and the cells were cultured overnight at 37°C under 5% CO_2 conditions. On the next day, the supernatant was removed, and the cells in the wells were washed once with PBS containing 5% FBS. Then, PE Mouse Anti-Human CD69 antibody (BD Biosciences) was added at a concentration of 20 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells in the wells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (FC500; Beckman Coulter Inc.). The data was analyzed using Flowjo

(Tree Star Inc.). The PE fluorescence intensity was plotted to a histogram. Hybridomas that yielded a sample exhibiting a shift to stronger fluorescence intensity in the fluorescence intensity histogram of PE than in the fluorescence intensity histogram of the rat IgG isotype control antibody were selected as anti-human CD3 antibody-producing hybridomas positive for the ability to activate human T cells.

[0212]

1)-6 Screening based on selective binding activity to human or monkey CD3 by flow cytometry

1)-6-1 Preparation of human antigen gene-expressing cells

Lenti-X293T cells (Takara Bio Inc., Cat# 632180) were added at a density of 5.3×10^4 cells/cm^2 to a 225-cm^2 flask and cultured overnight at 37°C under 5% CO_2 conditions in a DMEM medium containing 10% FBS. On the next day, hCD3ε-pcDNA3.1 and hCD3δ-pcDNA3.1 or a control pcDNA3.1-DEST was transfected to the Lenti-X293T cells using Lipofectamine 2000, and the cells were further cultured overnight at 37°C under 5% CO_2 conditions. On the next day, the expression vector-transfected Lenti-X293T cells were treated with TrypLE Express (Thermo Fisher Scientific Inc.), washed with DMEM containing 10% FBS, and then adjusted to a concentration of 5×10^6 cells/mL in PBS containing 5% FBS. The resulting cell suspension was used in flow cytometry analysis.

[0213]

1)-6-2 Flow cytometry analysis of binding activity to human CD3

The human CD3 binding specificity of the antibody produced by each hybridoma determined to be positive for the ability to activate human T cells in Example 1)-5 was further confirmed by flow cytometry. Each Lenti-X293T cell suspension prepared in Example 1)-6-1 was added at a concentration of 100 μL/well to a 96-well U-bottomed microplate and centrifuged to remove the supernatant. The hCD3ε-pcDNA3.1- and hCD3δ-pcDNA3.1-transfected Lenti-X293T cells or the pcDNA3.1-DEST-transfected Lenti-X293T cells were suspended by the addition of the hybridoma culture supernatant and left standing at 4°C for 1 hour. The cells were washed once with PBS containing 5% FBS, then suspended by the addition of Anti-Rat IgG FITC conjugate (Sigma-Aldrich Corp.) diluted 500-fold with PBS containing 5% FBS, and left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS and 2 μg/ml 7-aminoactinomycin D (Molecular Probes, Inc.), followed by detection using a flow cytometer. The data was analyzed using Flowjo. After removal of 7-aminoactinomycin D-positive dead cells by gating, the FITC fluorescence intensity of live cells was plotted to a histogram. Hybridomas that yielded a sample exhibiting a shift

to stronger fluorescence intensity in the histogram of the hCD3ε-pcDNA3.1- and hCD3δ-pcDNA3.1-transfected Lenti-X293T cells than in the fluorescence intensity histogram of the control pcDNA3.1-DEST-transfected Lenti-X293T cells were selected as hybridomas producing antibodies binding to human CD3.

[0214]

1)-6-3 Construction of monkey CD3εδ expression vector

cDNAs encoding the monkey CD3ε protein (NCBI Reference Sequence: NP_001270544.1) and the monkey CD3δ protein (NCBI Reference Sequence: NP_001274617.1) were amplified by PCR using a monkey T cell-derived cDNA as a template according to a method known to those skilled in the art, and cloned in pcDNA3.1(+) (Thermo Fisher Scientific Inc.) to construct expression vectors cynoCD3ε-pcDNA3.1 and cynoCD3δ-pcDNA3.1.

[0215]

1)-6-4 Preparation of monkey antigen gene-expressing cells

Lenti-X293T cells were inoculated at a density of 5.3×10^4 cells/cm^2 to a 225-cm^2 flask and cultured overnight at 37°C under 5% CO_2 conditions in a DMEM medium containing 10% FBS. On the next day, cynoCD3ε-pcDNA3.1 and cynoCD3δ-pcDNA3.1 or a control pcDNA3.1-DEST was transfected to the Lenti-X293T cells using Lipofectamine 2000, and the cells were further

cultured overnight at 37°C under 5% CO_2 conditions. On the next day, the expression vector-transfected Lenti-X293T cells were treated with TrypLE Express, washed with DMEM containing 10% FBS, and then adjusted to a concentration of 5×10^6 cells/mL in PBS containing 5% FBS. The resulting cell suspension was used in flow cytometry analysis.

[0216]

1)-6-5 Flow cytometry analysis of binding activity to monkey CD3

The monkey CD3 binding specificity of the antibody produced by each hybridoma determined to produce the antibody binding to human CD3 in Example 1)-6-2 was further confirmed by flow cytometry. Each Lenti-X293T cell suspension prepared in Example 1)-6-4 was added at a concentration of 100 μL/well to a 96-well U-bottomed microplate and centrifuged to remove a supernatant. The cynoCD3ε-pcDNA3.1- and cynoCD3δ-pcDNA3.1-transfected Lenti-X293T cells or the pcDNA3.1-DEST-transfected Lenti-X293T cells were suspended by the addition of the hybridoma culture supernatant and left standing at 4°C for 1 hour. The cells were washed once with PBS containing 5% FBS, then suspended by the addition of Anti-Rat IgG FITC conjugate diluted 500-fold with PBS containing 5% FBS, and left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS and 2 μg/ml 7-

aminoactinomycin D, followed by detection using a flow cytometer. The data was analyzed using Flowjo. After removal of 7-aminoactinomycin D-positive dead cells by gating, the FITC fluorescence intensity of live cells was plotted to a histogram. Hybridomas that yielded a sample exhibiting a shift to stronger fluorescence intensity in the histogram of the cynoCD3ε-pcDNA3.1- and cynoCD3δ-pcDNA3.1-transfected Lenti-X293T cells than in the fluorescence intensity histogram of the control pcDNA3.1-DEST-transfected Lenti-X293T cells were selected as hybridomas producing antibodies binding to monkey CD3.

[0217]

1)-6-6 Preparation of human CD3δ gene-expressing cells

Lenti-X293T cells were inoculated at a density of 5.3×10^4 cells/cm^2 to a 225-cm^2 flask and cultured overnight at 37°C under 5% CO_2 conditions in a DMEM medium containing 10% FBS. On the next day, hCD3δ-pcDNA3.1 or a control pcDNA3.1-DEST was transfected to the Lenti-X293T cells using Lipofectamine 2000, and the cells were further cultured overnight at 37°C under 5% CO_2 conditions. On the next day, the expression vector-transfected Lenti-X293T cells were treated with TrypLE Express, washed with DMEM containing 10% FBS, and then adjusted to a concentration of 5×10^6 cells/mL in PBS containing 5% FBS. The resulting cell suspension was used in

flow cytometry analysis.

[0218]

1)-6-7 Flow cytometry analysis of binding activity against human CD3δ

The human CD3δ binding specificity of the antibody produced by each hybridoma determined to produce the antibody binding to monkey CD3 in Example 1)-6-5 was further confirmed by flow cytometry. Each Lenti-X293T cell suspension prepared in Example 1)-6-6 was added at a concentration of 100 μL/well to a 96-well U-bottomed microplate and centrifuged to remove a supernatant. The hCD3δ-pcDNA3.1-transfected Lenti-X293T cells or the pcDNA3.1-DEST-transfected Lenti-X293T cells were suspended by the addition of the hybridoma culture supernatant and left standing at 4°C for 1 hour. The cells were washed once with PBS containing 5% FBS, then suspended by the addition of Anti-Rat IgG FITC conjugate diluted 500-fold with PBS containing 5% FBS, and left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS and 2 μg/ml 7-aminoactinomycin D, followed by detection using a flow cytometer. The data was analyzed using Flowjo. After removal of 7-aminoactinomycin D-positive dead cells by gating, the FITC fluorescence intensity of live cells was plotted to a histogram. Hybridomas that yielded a sample exhibiting a shift to stronger fluorescence intensity

in the histogram of the hCD3δ-pcDNA3.1-transfected Lenti-X293T cells than in the fluorescence intensity histogram of the control pcDNA3.1-DEST-transfected Lenti-X293T cells were excluded as hybridomas producing antibodies binding to human CD3δ.

[0219]

1)-6-8 Flow cytometry analysis of binding activity to monkey T cell lines

The monkey T cell line binding specificity of the antibody produced by each antibody-producing hybridoma that was not excluded in Example 1)-6-7 was further confirmed by flow cytometry. A cynomolgus monkey T cell line HSC-F (JCRB Cell Bank, No. JCRB1164) was adjusted to a concentration of 5×10^6 cells/mL in an RPMI1640 medium containing FBS and added at a concentration of 100 μL/well to a 96-well plate. After removal of the supernatant by centrifugation, the culture supernatant of the antibody-producing hybridoma that was not excluded in Example 1)-5- 7, or a rat IgG isotype control antibody was added to the HSC-F cells, and the plate was left standing at 4°C for 1 hour. Then, the supernatant was removed, and the cells in the wells were washed once with PBS containing 5% FBS, then suspended by the addition of Anti-Rat IgG FITC conjugate diluted 500-fold with PBS containing 5% FBS, and left standing at 4°C for 1 hour. The cells were washed three times with PBS containing 5% FBS and

then resuspended in PBS containing 5% FBS and 2 μg/ml 7-aminoactinomycin D, followed by detection using a flow cytometer. The data was analyzed using Flowjo. After removal of 7-aminoactinomycin D-positive dead cells by gating, the FITC fluorescence intensity of live cells was plotted to a histogram. Hybridomas that yielded a sample exhibiting a shift to stronger fluorescence intensity in the fluorescence intensity histogram of FITC than in the fluorescence intensity histogram of the rat IgG isotype control antibody were selected as hybridomas producing antibodies also binding to the monkey T cell line.

[0220]

1)-7 Isotyping of antibodies

C3-147 suggestive of binding to human and monkey CD3ε and also binding to a monkey T cell line, and having the high ability to activate human T cells was selected from among the rat anti-CD3 antibody-producing hybridomas obtained in Example 1)-6, and identified by antibody isotyping. The isotype was determined using Rat Immunoglobulin Isotyping ELISA Kit (BD Pharmingen). As a result, the isotype of the rat anti-CD3 monoclonal antibody C3-147 was confirmed to be IgG2b and λ chains.

[0221]

(Example 2) Study of the binding activity of rat anti-CD3 monoclonal antibodies (C3-147) to human CD3

2)-1 Preparation of monoclonal antibodies from

hybridoma supernatant

2)-1-1 Culture of hybridoma producing C3-147

The rat anti-CD3 monoclonal antibody was purified from the hybridoma culture supernatant. First, the C3-147-producing hybridoma was allowed to grow to a sufficient amount in ClonaCell-HY Selection Medium E (StemCell Technologies Inc.). Then, the medium was replaced with a Hybridoma SFM (Thermo Fisher Scientific Inc.) containing 5 μg/mL gentamicin (Thermo Fisher Scientific Inc.) supplemented with 20% Ultra Low IgG FBS (Thermo Fisher Scientific Inc.), followed by culturing for 7 days. This cultured supernatant was recovered and sterilized through a 0.22 μm filter (Corning Inc.).

[0222]

2)-1-2 Purification

The antibody was purified by protein G affinity chromatography from the hybridoma culture supernatant prepared in Example 2)-1-1. The antibody was adsorbed onto a protein G column (GE Healthcare Bio-Sciences Corp.), and the column was washed with PBS, followed by elution with an aqueous solution of 0.1 M glycine/hydrochloric acid (pH 2.7). The eluate was adjusted to pH 7.0 to 7.5 by the addition of 1 M Tris-HCl (pH 9.0). Then, the buffer was replaced with PBS using Centrifugal UF Filter Device VIVASPIN20 (molecular weight cutoff: UF30K, Sartorius Japan K.K.) while the antibody was concentrated and

adjusted to an antibody concentration of 2 mg/mL. Finally, the concentrate was filtered through a Minisart-Plus filter (Sartorius Japan K.K.) and used as a purified sample.

[0223]

2)-2 Binding of obtained rat anti-CD3 antibody (C3-147) to human single-chain antigens

2)-2-1 Preparation of human CD3εγ single-chain antigens

An amino acid sequence encoding CD3ε or CD3γ was obtained from the crystal structure (PDBID: 1SY6) of an OTK3-human CD3εγ single-chain antigen complex submitted to the protein data bank. The same peptide linker composed of 26 amino acids that was reported in the reference (Kim, K.S. et al., (2000) J. Mol. Biol. 302, 899-916) was used as a linker for connecting the carboxyl terminus of CD3ε to the amino terminus of CD3γ. The gene encoding the human CD3εγ single-chain antigen shown in Figure 3 (SEQ ID NO: 4) of the Sequence Listing was synthesized by adding restriction sites BamHI and HindIII to the 5' and 3' ends, respectively (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). A fragment of approximately 4.8 kb obtained by digesting a plasmid pQE80L (Qiagen N.V.) with restriction enzymes BamHI and HindIII was ligated with a fragment of approximately 0.6 kb obtained by digesting the human CD3εγ single-chain antigen gene with BamHI and

HindIII, using Ligation High (Toyobo Co., Ltd.) to prepare a plasmid pQE80L-scCD3εγ for expression in *E. coli*. The amino acid sequence of the resulting scCD3εγ is described in Figure 4 (SEQ ID NO: 5) of the Sequence Listing. *E. coli* BL21 (DE3) for expression was transformed with the plasmid pQE80L-scCD3εγ for expression, and the resulting colony was added to 1 L MagicMedia (Invitrogen Corp.) using Ultra Yield flasks™ (Thomson Instrument Company) and shake-cultured at 250 rpm at 30°C for 21 hours. The bacterial cells thus cultured were recovered. Bacterial cells were disrupted using an ultrasonic homogenizer in the presence of a Tris buffer solution containing a 1% Triton solution, and the freeze-thaw cycle was repeated. Finally, inclusion bodies were recovered by centrifugation at 15000 rpm at 4°C for 15 minutes. The procedures from refolding of the inclusion bodies to purification were performed according to the approach of the reference (Kjer-Nielsen et al. (2004) PNAS vol. 101, no. 20, 7675-7680) except that the anti-CD3 antibody used in an antibody column was a mouse anti-CD monoclonal antibody OKT3 (Sgro, Toxicology 105 (1995), 23-29, Orthoclone, Janssen-Cilag) instead of 2C11 used in the literature.

[0224]

2)-2-2 SPR measurement of binding activity to human CD3εγ single-chain antigens

The antibody was assayed for its binding to the antigen using BIAcore 3000 (GE Healthcare Bio-Sciences Corp.) by the capture method, which involves capturing the antibody as a ligand on an immobilized anti-mouse IgG antibody and assaying the antigen as an analyte. The antigen used was the human CD3εγ prepared in Example 2)-2-1. Approximately 11000 RU of the anti-mouse IgG antibody (Mouse Antibody Capture Kit, GE Healthcare Bio-Sciences Corp.) was covalently bound to a sensor chip CM5 (GE Healthcare Bio-Sciences Corp.) by the amine coupling method. Similarly, this antibody was immobilized onto a reference cell. The running buffer used was HBS-EP+ (10 mM HEPES (pH 7.4), 0.15 M NaCl, 3 mM EDTA, and 0.05% Surfactant P20). The antibody was added onto the anti-mouse IgG antibody-immobilized chip for approximately 1 minute and then captured as a ligand. Then, 100 nM of the antigen was added at a flow rate of 30 μl/min for 120 seconds, and the binding to the antigen was monitored. 10 mM glycine-HCl (pH 1.7) was added as a regenerating solution at a flow rate of 10 μl/min for 3 minutes. As a result, the binding signal of C3-147 after 120 seconds was 34 RU.

[0225]

2)-3 Confirmation of the antigen-binding site in the resulting rat anti-CD3 antibody (C3-147) by SPR

The method for confirming an antigen-binding

site was performed in the same manner as Example 2)-2-2. As a result, the binding signal obtained for C3-147 was 34 RU. On the other hand, an antigen-binding site in SP34 (BD Pharmingen), an anti-CD3 antibody known in the art, was similarly confirmed as a comparative example. The binding signal of 34 RU was not observed in SP34. These results indicated that a binding site on the CD3εγ surface recognized by C3-147 is different from that recognized by SP34.

[0226]

(Example 3) Sequencing of cDNAs encoding variable regions in rat anti-CD3 antibodies (C3-147)

The cDNAs encoding the variable regions of the rat anti-CD3 antibody (C3-147) were sequenced by the following method.

[0227]

3)-1 cDNA synthesis

Cell lysates (50 mM Tris-HCl (pH 7.5), 250 mM LiCl, 5 mM EDTA (pH 8), 0.5% lithium dodecyl sulfate (LiDS), and 2.5 mM dithiothreitol (DTT)) of the rat anti-CD3 antibody (C3-147)-producing hybridoma were mixed with oligo dT25-bound magnetic beads of Dynabeads mRNA DIRECT Kit (Thermo Fisher Scientific Inc.) so that the mRNA was bound to the magnetic beads. Next, the magnetic beads were washed once each with mRNA washing solution A (10 mM Tris-HCl (pH 7.5), 0.15 M LiCl, 1 mM EDTA, 0.1% LiDS, and 0.1% Triton X-100) and a solution for cDNA synthesis (50 mM Tris-

HCl (pH 8.3), 75 mM KCl, 3 mM MgCl2, 5 mM DTT, 0.5 mM dNTP, 0.2% Triton X-100, and 1.2 units of RNase inhibitor (Thermo Fisher Scientific Inc.). Then, a cDNA was synthesized using a solution for cDNA synthesis supplemented with 12 units of SuperScript III Reverse Transcriptase (Thermo Fisher Scientific Inc.). Subsequently, the cDNA was washed with a 3' tailing reaction solution (50 mM potassium phosphate, 4 mM MgCl2, 0.5 mM dGTP, 0.2% Triton X-100, and 1.2 units of RNase inhibitor), followed by 3' tailing reaction with a reaction solution supplemented with 48 units of Terminal Transferase, recombinant (Roche Applied Science).

[0228]

3)-2 Amplification and sequencing of rat immunoglobulin heavy and light chain variable region gene fragments

The magnetic beads were washed with a TE solution (10 mM Tris-HCl (pH 7.5), 1 mM EDTA, and 0.1% Triton X-100). Then, the rat immunoglobulin heavy and light chain genes were amplified by 5'-RACE PCR. Specifically, the magnetic beads were transferred to a PCR reaction solution (0.2 μM primers, 0.2 mM dNTP, and 0.25 units of PrimeSTAR HS DNA Polymerase (Takara Bio Inc.)) and subjected to 35 reaction cycles each involving 94°C for 30 seconds and 68°C for 90 seconds. The primer sets used are described below.

PCR primer set for heavy chain gene amplification

Sense primer Nhe-polyC-S

5'-GCTAGCGCTACCGGACTCAGATCCCCCCCCCCCCCDN-3'; Figure 5 (SEQ ID NO: 50)

First antisense primer rIgγ-AS1

5'-TCACTGAGCTGGTGAGAGTGTAGAGCCC-3'; Figure 6 (SEQ ID NO: 51)

Second antisense primer rIgγ-AS2

5'-TCACCGAGCTGCTGAGGGTGTAGAGCCC-3'; Figure 7 (SEQ ID NO: 52)

PCR primer set for light chain gene amplification

Sense primer Nhe-polyC-S2

5'-GCTAGCGCTACCGGACTCAGATCCCCCCCCCCCCCDN-3'; Figure 8 (SEQ ID NO: 53)

First antisense primer rIgL-AS1

5'-TTCCACATCACTCGGGTAGAAATCAG-3'; Figure 9 (SEQ ID NO: 54)

Second antisense primer rIgγ-AS2

5'-TAACACCAGGGTAGAAATCTGTCACCAT-3'; Figure 10 (SEQ ID NO: 55)

Sequence analysis was carried out on the nucleotide sequences of the fragments amplified by the PCR reaction. The primers used are described below.

Sense primer rIgγ-seq for heavy chain sequencing

5'-CTGGCTCAGGGAAATAGCC-3'; Figure 11 (SEQ ID NO: 56)

Antisense primer rIgL-seq1 for light chain sequencing

5'-TCCCTGGAGCTCCTCAGT-3'; Figure 12 (SEQ ID NO: 57)

Antisense primer rIgL-seq2 for light chain sequencing 5'-GCCTTGTCAGTCTTGAGC-3'; Figure 13 (SEQ ID NO: 58)

The sequence analysis was carried out using a gene sequence analyzer ("ABI PRISM 3700 DNA Analyzer; Applied Biosystems, Inc." or "Applied Biosystems 3730xl Analyzer; Applied Biosystems, Inc."). The Dye Terminator Cycle Sequencing System with AmpliTaq DNA polymerase (Life Technologies Corp.) and GeneAmp 9700 (Applied Biosystems, Inc.) were used in sequencing reaction.

The nucleotide sequence of the C3-147 heavy chain variable region determined by the sequence analysis is described in Figure 14 (SEQ ID NO: 6), and its amino acid sequence is described in Figure 15 (SEQ ID NO: 7). The nucleotide sequence of the C3-147 light chain variable region is described in Figure 16 (SEQ ID NO: 8), and its amino acid sequence is described in Figure 17 (SEQ ID NO: 9).

[0229]

(Example 4) Preparation of rat anti-CD3 scFv (C3E-7000) and its humanized form (C3E-7034)

4)-1 Preparation of rat anti-CD3 antibody (C3-147) scFv

4)-1-1 Construction of rat antibody CD3 scFv expression vector (pC3E-7000)

A sense strand oligonucleotide (Figure 18 (SEQ ID NO: 10)) of a DNA fragment having 15-base additional sequences upstream and downstream of a DNA

sequence encoding a linker to be inserted between the heavy chain variable region (VH) and the light chain variable region (VL) of C3-147, and an antisense strand oligonucleotide thereof (Figure 19 (SEQ ID NO: 11)) were synthesized (Sigma-Aldrich Corp., Custom Oligo Synthesis Service), and adjusted to 100 pmol/μL. Then, 20 μL each of these oligonucleotides was mixed and left standing at 96°C for 10 minutes, at 70°C for 2 minutes, at 60°C for 2 minutes, at 40°C for 2 minutes, and at 30°C for 2 minutes for annealing to prepare a DNA fragment of the linker to be inserted between VH and VL. Next, a DNA fragment amplified by PCR to add a human IgG heavy chain signal sequence, the DNA fragment (shown in Figure 14 (SEQ ID NO: 6)) of VH of the rat anti-CD3 antibody C3-147 amplified by PCR, the DNA fragment of the linker to be inserted between VH and VL, and a DNA fragment amplified by PCR in which a DNA sequence encoding a FLAG-His tag was added to a region containing the C3-147 VL DNA sequence (shown in Figure 16 (SEQ ID NO: 8)) such that the FLAG-His tag was located at the carboxyl terminus, were ligated with a vector backbone derived from an expression vector pcDNA-3.3TOPO for animal cells (Thermo Fisher Scientific Inc.) using In-Fusion HD cloning kit (Clontech Laboratories, Inc.) to prepare an scFv expression vector pC3E-7000 containing the nucleotide sequence of Figure 20 (SEQ ID NO: 14) in ORF.

[0230]

4)-1-2 Expression and purification of rat anti-CD3 scFv (C3E-7000)

Expi293F cells (Thermo Fisher Scientific Inc.) were subcultured and cultured according to the manual. The scFv expression vector was transfected to the Expi293F cells in the logarithmic growth phase. The scFv was transiently expressed, filtered, and then used in purification. The purification was performed by two steps involving Ni affinity chromatography using His Trap Excel (GE Healthcare Bio-Sciences Corp.) and gel filtration using Superdex 200 increase (GE Healthcare Bio-Sciences Corp.). A peak corresponding to the molecular weight of the scFv monomer was recovered and used as a purified protein sample. For the purification, AKTA chromatography system was used, and all steps were performed at 4°C. HBSor (25 mM histidine/5% sorbitol, pH 5.0) was used as a buffer for the purified protein. The purified protein sample was applied to SEC for analysis to determine its purity and concentration. Then, the sample was used in various assays. The amino acid sequence in C3E-7000 is described in Figure 21 (SEQ ID NO: 15).

[0231]

4)-2 Humanization of rat anti-CD3 scFv (C3E-7000)

4)-2-1 Humanization design of anti-CD3 antibody

The molecular modeling of the variable regions of the rat antibody was performed according to a method known in the art as homology modeling (Methods in Enzymology, 203, 121-153, (1991)) using a commercially available protein three-dimensional structure analysis program Discovery Studio 3.5 (Dassault Systems S.A.).

[0232]

The humanization was performed by a method generally known as CDR grafting (Proc. Natl. Acad. Sci. USA 86, 10029-10033 (1989)). An acceptor antibody was selected from human subgroup consensus sequences specified by KABAT et al. (Sequences of Proteins of Immunological Interest, 5th Ed. Public Health Service National Institutes of Health, Bethesda, MD. (1991)) or the germline sequences on the basis of amino acid identity within framework regions, expected immunogenicity prediction scores or physical properties, etc. Also, back mutation was selected with reference to criteria, etc., provided by Queen et al. (PNAS (1989) 86, 10029-10033) through the use of the three-dimensional structure model constructed by the approach described above.

[0233]

4)-2-2 Design of humanized amino acid sequence C3E-7000

On the basis of the approach described in Example 4)-2-1, the amino acid sequence of C3E-7034

serving as a humanized form of C3E-7000 was designed with human subgroup consensus sequences γ3 and λ6 as acceptors. The amino acid sequence of C3E-7034VH designed from the amino sequence of C3-147VH shown in Figure 15 (SEQ ID NO: 7) by the replacement of arginine at amino acid position 16 with glycine, alanine at amino acid position 17 with serine, lysine at amino acid position 19 with arginine, valine at amino acid position 23 with alanine, valine at amino acid position 24 with alanine, serine at amino acid position 88 with alanine, and threonine at amino acid position 93 with valine is described in Figure 22 (SEQ ID NO: 16).

[0234]

The amino acid sequence of C3E-7034VL designed from the amino sequence of C3-147VL shown in Figure 17 (SEQ ID NO: 9) by the replacement of glutamine at amino acid position 1 with asparagine, valine at amino acid position 3 with methionine, asparagine at amino acid position 8 with histidine, threonine at amino acid position 12 with glutamic acid, asparagine at amino acid position 13 with serine, leucine at amino acid position 14 with proline, threonine at amino acid position 16 with lysine, glutamic acid at amino acid position 19 with threonine, leucine at amino acid position 20 with isoleucine, arginine at amino acid position 43 with serine, leucine at amino acid position 75 with serine, asparagine at amino

acid position 79 with serine, valine at amino acid position 81 with leucine, and glutamine at amino acid position 82 with lysine is described in Figure 23 (SEQ ID NO: 17).

The CDR sequences of C3E-7000 and C3E-7034 based on the CDR definition of IMGT are described in Figure 24 (SEQ ID NO: 26) for CDR-H1, Figure 25 (SEQ ID NO: 27) for CDR-H2, Figure 26 (SEQ ID NO: 28) for CDR-H3, Figure 27 (SEQ ID NO: 29) for CDR-L1, Figure 28 (SEQ ID NO: 30) for CDR-L2, and Figure 29 (SEQ ID NO: 31) for CDR-L3.

[0235]

4)-2-3 Modification of humanized anti-CD3 scFv C3E-7034

In order to prepare variants having distinctive binding activity and cytotoxic activity while maintaining cross-reactivity with monkey CD3ε, variants were designed, in the same way as in the approach described in Example 4)-2-1, by the replacement of amino acids in the framework regions of VL of C3E-7034 with the corresponding ones in VL of scFv (sequence containing the four mutations A2S, S8P, V13A, and F80L in IGLV1-40*01).

[0236]

4)-2-3-1 Amino acid sequence design of C3E-7035

The amino acid sequence of C3E-7035 serving as a variant of C3E-7034 was designed. The amino acid sequence of the C3E-7035 light chain designed from

the C3E-7034 light chain variable region shown in Figure 23 (SEQ ID NO: 17) by the replacement of asparagine at amino acid position 1 with glutamine, the replacement of phenylalanine at amino acid position 2 with alanine, the replacement of methionine at amino acid position 3 with valine, the replacement of histidine at amino acid position 8 with serine, the replacement of glutamic acid at amino acid position 12 with glycine, the replacement of serine at amino acid position 13 with valine, the replacement of lysine at amino acid position 16 with glutamine, the replacement of threonine at amino acid position 17 with arginine, the replacement of histidine at amino acid position 40 with leucine, the replacement of glutamic acid at amino acid position 41 with proline, the replacement of serine at amino acid position 43 with threonine, the replacement of serine at amino acid position 44 with alanine, the replacement of threonine at amino acid position 46 with lysine, the replacement of threonine at amino acid position 47 with leucine, the replacement of isoleucine at amino acid position 48 with leucine, the replacement of aspartic acid at amino acid position 57 with serine, the replacement of serine at amino acid position 60 with proline, the replacement of isoleucine at amino acid position 67 with lysine, the deletion of aspartic acid at amino acid position 68, the deletion of arginine at amino

acid position 69, the replacement of serine at amino acid position 71 with glycine, the replacement of lysine at amino acid position 72 with threonine, the replacement of threonine at amino acid position 77 with alanine, the replacement of serine at amino acid position 79 with threonine, the replacement of asparagine at amino acid position 80 with glycine, the replacement of leucine at amino acid position 81 with phenylalanine, the replacement of lysine at amino acid position 82 with glutamine, the replacement of threonine at amino acid position 83 with alanine, and the replacement of phenylalanine at amino acid position 90 with tyrosine is described in Figure 30 (SEQ ID NO: 20). The full-length sequence of C3E-7035 containing methionine and alanine inserted immediately before the light chain variable region is described in Figure 31 (SEQ ID NO: 22) of the Sequence Listing.

[0237]

4)-2-3-2 Amino acid sequence design of C3E-7036

The amino acid sequence of C3E-7036 serving as a variant of C3E-7034 was designed. The amino acid sequence of the C3E-7036 light chain designed from the C3E-7034 light chain variable region shown in Figure 23 (SEQ ID NO: 17) by the replacement of histidine at amino acid position 8 with serine, the replacement of glutamic acid at amino acid position 12 with glycine, the replacement of serine at amino

acid position 13 with valine, the replacement of lysine at amino acid position 16 with glutamine, the replacement of threonine at amino acid position 17 with arginine, the replacement of lysine at amino acid position 23 with threonine, the replacement of arginine at amino acid position 24 with glycine, the replacement of histidine at amino acid position 40 with leucine, the replacement of glutamic acid at amino acid position 41 with proline, the replacement of serine at amino acid position 43 with threonine, the replacement of serine at amino acid position 44 with alanine, the replacement of threonine at amino acid position 46 with lysine, the replacement of threonine at amino acid position 47 with leucine, the replacement of isoleucine at amino acid position 48 with leucine, the replacement of aspartic acid at amino acid position 57 with serine, the replacement of serine at amino acid position 60 with proline, the replacement of isoleucine at amino acid position 67 with lysine, the deletion of aspartic acid at amino acid position 68, the deletion of arginine at amino acid position 69, the replacement of serine at amino acid position 71 with glycine, the replacement of lysine at amino acid position 72 with threonine, the replacement of threonine at amino acid position 77 with alanine, the replacement of serine at amino acid position 79 with threonine, the replacement of asparagine at amino acid position 80 with glycine,

the replacement of leucine at amino acid position 81 with phenylalanine, the replacement of lysine at amino acid position 82 with glutamine, the replacement of threonine at amino acid position 83 with alanine, and the replacement of phenylalanine at amino acid position 90 with tyrosine is described in Figure 32 (SEQ ID NO: 23). The full-length amino acid sequence of C3E-7036 is described in Figure 33 (SEQ ID NO: 25).

[0238]

4)-2-3-3 Amino acid design in CDR variants

For the purpose of removing a deamination site present in C3E-7034 CDRH2 (Figure 25, SEQ ID NO: 27), C3E-7078 having arginine substituted for asparagine at amino acid position 53 in the C3E-7034 heavy chain variable region shown in Figure 22 (SEQ ID NO: 16) and C3E-7079 having serine substituted therefor were designed. Also, C3E-7085 having arginine substituted for asparagine at amino acid position 53 in the C3E-7036 heavy chain variable region was designed. The entire amino acid sequence of C3E-7078 is listed in Figure 68 (SEQ ID NO: 60). The entire amino acid sequence of C3E-7079 is listed in Figure 70 (SEQ ID NO: 62). The entire amino acid sequence of C3E-7085 is listed in Figure 72 (SEQ ID NO: 64).

For the purpose of reducing the affinity of C3E-7078 for human CD3, C3E-7086 having glycine substituted for aspartic acid at amino acid position

52 in the C3E-7078 light chain variable region, C3E-7087 having glutamine substituted therefor, C3E-7088 having asparagine substituted therefor, C3E-7089 having serine substituted therefor, and C3E-7090 having alanine substituted therefor were designed. Likewise, for the purpose of reducing the affinity of C3E-7079 for human CD3, C3E-7091 having glycine substituted for aspartic acid at amino acid position 52 in the C3E-7079 light chain variable region, C3E-7092 having glutamine substituted therefor, C3E-7093 having asparagine substituted therefor, C3E-7094 having serine substituted therefor, and C3E-7095 having alanine substituted therefor were designed. The entire amino acid sequence of C3E-7086 is listed in Figure 74 (SEQ ID NO: 66). The entire amino acid sequence of C3E-7087 is listed in Figure 76 (SEQ ID NO: 68). The entire amino acid sequence of C3E-7088 is listed in Figure 78 (SEQ ID NO: 70). The entire amino acid sequence of C3E-7089 is listed in Figure 80 (SEQ ID NO: 72). The entire amino acid sequence of C3E-7090 is listed in Figure 82 (SEQ ID NO: 74). The entire amino acid sequence of C3E-7091 is listed in Figure 84 (SEQ ID NO: 76). The entire amino acid sequence of C3E-7092 is listed in Figure 86 (SEQ ID NO: 78). The entire amino acid sequence of C3E-7093 is listed in Figure 88 (SEQ ID NO: 80). The entire amino acid sequence of C3E-7094 is listed in Figure 90 (SEQ ID NO: 82). The entire amino acid sequence

of C3E-7095 is listed in Figure 92 (SEQ ID NO: 84).

[0239]

4)-3 Preparation of humanized anti-CD3 scFv (C3E-7034, C3E-7035, and C3E-7036)

4)-3-1 Construction of humanized anti-CD3 scFv (C3E-7034) expression vector pC3E-7034

A DNA fragment comprising a DNA sequence of scFv containing a C3E-7034 light chain (shown in Figure 23 (SEQ ID NO: 17)) connected to the carboxyl terminus of the C3E-7034 heavy chain (shown in Figure 22 (SEQ ID NO: 16)) via a 15-amino acid flexible linker was synthesized with 15-base additional sequences attached upstream and downstream (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). A region containing the C3E-7034 DNA and additional sequences upstream and downstream was amplified by PCR using this DNA fragment as a template to obtain an insert DNA fragment. A vector region except for the scFv region was amplified by PCR using the expression vector pC3E-7000 prepared in Example 4)-1-1 as a template to obtain a vector fragment. These DNA fragments were annealed using In-Fusion HD cloning kit (Clontech Laboratories, Inc.) to prepare a humanized anti-CD3 scFv expression vector pC3E-7034 containing the nucleotide sequence of Figure 34 (SEQ ID NO: 18) in ORF.

[0240]

4)-3-2 Construction of humanized anti-CD3 scFv

(C3E-7035) expression vector pC3E-7035

A DNA fragment comprising a DNA sequence of scFv containing the C3E-7035 light chain (shown in Figure 30 (SEQ ID NO: 20)) connected to the carboxyl terminus of the C3E-7034 heavy chain (shown in Figure 22 (SEQ ID NO: 16)) via a 17-amino acid flexible linker was synthesized with 15-base additional sequences attached upstream and downstream (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). A C3E-7035 expression vector containing the nucleotide sequence of Figure 35 (SEQ ID NO: 21) in ORF was constructed in the same way as in Example 4)-3-1. The resulting expression vector was designated as "pC3E-7035."

[0241]

4)-3-3 Construction of humanized anti-CD3 scFv (C3E-7036) expression vector pC3E-7036

A DNA fragment comprising a DNA sequence of scFv containing the C3E-7036 light chain (shown in Figure 32 (SEQ ID NO: 23)) connected to the carboxyl terminus of the C3E-7034 heavy chain (shown in Figure 22 (SEQ ID NO: 16)) via a 15-amino acid flexible linker was synthesized with 15-base additional sequences attached to its upstream and downstream (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). A C3E-7036 expression vector containing the nucleotide sequence of Figure 36 (SEQ ID NO: 24) in ORF was constructed in the same manner

as in Example 4)-3-1. The resulting expression vector was designated as "pC3E-7036."

[0242]

4)-3-4 Construction of CDR modified humanized antibody CD3 scFv expression vectors

PCR-based site-directed mutagenesis was performed using pC3E-7034 containing the nucleotide sequence of C3E-7034 shown in Figure 34 (SEQ ID NO: 18) in ORF as a template and using primers having the nucleotide sequences shown in Figures 93 and 94 (SEQ ID NOs: 85 and 86) to prepare a C3E-7078 expression vector containing the nucleotide sequence of C3E-7078 having arginine substituted for asparagine at amino acid position 53 in the C3E-7034 heavy chain variable region, in ORF. The resulting expression vector was designated as "pC3E-7078." Likewise, PCR-based site-directed mutagenesis was performed using pC3E-7034 as a template and using primers of Figures 95 and 96 (SEQ ID NOs: 87 and 88) to prepare a C3E-7079 expression vector containing the nucleotide sequence of C3E-7079 having serine substituted for asparagine at amino acid position 53 in the C3E-7034 heavy chain variable region. The resulting expression vector was designated as "pC3E-7079." Likewise, PCR-based site-directed mutagenesis was performed using pC3E-7036 as a template and using primers of Figures 93 and 94 (SEQ ID NOs: 85 and 86) to prepare a C3E-7085 expression vector containing the nucleotide sequence

of C3E-7085 having arginine substituted for asparagine at amino acid position 53 in the C3E-7036 heavy chain variable region. The resulting expression vector was designated as "pC3E-7085."

[0243]

Expression vectors containing the nucleotide sequence of C3E-7086 having glycine substituted for aspartic acid at amino acid position 52 in the C3E-7078 light chain variable region, C3E-7087 having glutamine substituted therefor, C3E-7088 having asparagine substituted therefor, C3E-7089 having serine substituted therefor, or C3E-7090 having alanine substituted therefor in ORF, and expression vectors containing the nucleotide sequence of C3E-7091 having glycine substituted for aspartic acid at amino acid position 52 in the C3E-7079 light chain variable region, C3E-7092 having glutamine substituted therefor, C3E-7093 having asparagine substituted therefor, C3E-7094 having serine substituted therefor, or C3E-7095 having alanine substituted therefor in ORF were also prepared by the same approach as above. A list of the names of the prepared vectors, templates, and primers is summarized in Table 1, and a primer list is summarized in Figure 105.

[0244]

[Table 1]

Clone ID	Template	Forward primer	Reverse primer
C3E-7086	C3E-7078	LD52G Fw	LD52G Rv
C3E-7087	C3E-7078	LD52Q Fw	LD52Q Rv
C3E-7088	C3E-7078	LD52N Fw	LD52N Rv
C3E-7089	C3E-7078	LD52S Fw	LD52S Rv
C3E-7090	C3E-7078	LD52A Fw	LD52A Rv
C3E-7091	C3E-7079	LD52G Fw	LD52G Rv
C3E-7092	C3E-7079	LD52Q Fw	LD52Q Rv
C3E-7093	C3E-7079	LD52N Fw	LD52N Rv
C3E-7094	C3E-7079	LD52S Fw	LD52S Rv
C3E-7095	C3E-7079	LD52A Fw	LD52A Rv

[0245]

4)-3-5 Expression and purification of humanized anti-CD3 scFv

C3E-7034, C3E-7035, and C3E-7036 were expressed and purified in the same manner as in Example 4)-1-2.

[0246]

4)-3-6 Expression and purification of CDR modified humanized anti-CD3 scFv

The CDR variants C3E-7078, C3E-7079, C3E-7085, C3E-7086, C3E-7087, C3E-7088, C3E-7089, C3E-7090, C3E-7091, C3E-7092, C3E-7093, C3E-7094, and C3E-7095 were expressed and purified in the same manner as in Example 4)-1-2.

[0247]

(Example 5) Crystal structure analysis of humanized anti-CD3 scFv (C3E-7034)

5)-1 Preparation of a humanized anti-CD3 scFv (C3E-7034)-human CD3εγ single-chain antigen complex

CD3εγ prepared in Example 2)-2-1 and C3E-7034 prepared in Example 4)-3-1 were mixed at a molar ratio of 1:2. The buffer solution was replaced with 10 mM Tris HCl (pH 7.5) and 50 mM NaCl using Amicon Ultra 15 MWCO 10K (Merck Millipore), and the resulting solution was concentrated to 3.5 mg/mL. This concentrate was purified by gel filtration chromatography using Superdex 200 10/300GL (GE Healthcare Bio-Sciences Corp.). A fraction of the complex was concentrated into approximately 4.0 mg/mL using Amicon Ultra 15 MWCO 10K (Millipore).

[0248]

5)-2 Crystallization

The resulting complex of CD3εγ and C3E-7034 was crystallized by the vapor diffusion method. To 0.5 μL of the protein solution, an equal amount of a precipitant solution (0.1 M MES monohydrate (pH 6.5), 1.6 M ammonium sulfate, and 10% v/v 1,4-dioxane) was added, and the resulting solution was placed in a sealed container containing 0.05 mL of a precipitant solution so that the solutions had no contact with each other. The container was left standing at 25°C. One month later, 0.1 mm × 0.05 mm × 0.05 mm rod-like crystals were obtained.

[0249]

5)-3 X-ray crystal structure analysis and

identification of epitope

The resulting crystal was dipped in Perfluoropolyether PFO-X175/08 (Hampton Research Corp.) and subsequently frozen in liquid nitrogen. X-ray diffraction data was collected using beamline BL41XU (SPring-8, Hyogo, Japan). The diffraction intensity was digitized from the resulting diffraction image using software imosflm (CCP4: Collaborative Computational Project No. 4) to determine crystal structure factors. The crystals were in a hexagonal system with a space group of P62 and unit cells of a = 193.54 angstroms, b = 193.54 angstroms, and c = 43.88 angstroms.

[0250]

The molecular replacement method was performed using the resulting structural factors and the three-dimensional structural coordinates of the homology models to determine phases. A software phaser (CCP4: Collaborative Computational Project No. 4) was used in calculation. The crystals contained one complex in an asymmetric unit.

Structure refinement was performed using software Refmac5 (CCP4: Collaborative Computational Project No. 4), and model correction was performed using Coot software. This operation was performed repeatedly to obtain a final R factor of 22.1% and a free R factor of 27.0% with a resolution of 3.3 angstroms. The final model contained amino acid

residues 1 to 108 of the C3E-7034 light chain region (Figure 23, SEQ ID NO: 17), amino acid residues 1 to 118 of the C3E-7034 heavy chain region (Figure 22, SEQ ID NO: 16), amino acid residues 33 to 67 and 71 to 118 of the CD3ε region (Figure 1, SEQ ID NO: 1), and amino acid residues 23 to 103 of the CD3γ region (Figure 37, SEQ ID NO: 3). Amino acid residues 68 to 70 of the CD3ε region (Figure 1, SEQ ID NO: 1), and the amino-terminal region (amino acid residue 1), the linker portion (amino acid residues 120 to 134), and the carboxyl-terminal region (amino acid residues 243 to 269) of C3E-7034 (Figure 38, SEQ ID NO: 19) were not included in the model because of their obscure electric density. Figure 39 shows the ribbon model of the whole complex, and the surface.

Figure 40 shows the interaction between CD3ε and the light and heavy chains of C3E-7034. Panel A is a diagram in which the amino acids of CD3ε having a distance within 4 angstroms of the light chain variable region of C3E-7034 are indicated by thick sticks in the model, and the other amino acids are indicated by thin sticks in the model. In the diagram, Ser55, Glu56, Arg101, Gly102, Ser103, Lys104, and Pro105 denoted by residue name and residue no. inside boxes are amino acid residues of CD3ε having a distance within 4 angstroms of the light chain variable region of C3E-7034, and each amino acid position corresponds to a position in SEQ ID NO: 1

of the Sequence Listing. Panel B is a diagram in which the amino acid residues of CD3ε having a distance within 4 angstroms of the heavy chain variable region of C3E-7034 are indicated by thick sticks in the model, and the other amino acids are indicated by thin sticks in the model. In the diagram, Ser55, Glu56, Leu58, Trp59, Asn65, Ile66, Ser77, Asp78, and Arg101 denoted by residue name and residue no. inside boxes are amino acids of CD3ε, and each amino acid position corresponds to the position in SEQ ID NO: 1 of the Sequence Listing. The following amino acid residues have a distance within 4 angstroms of C3E-7034 and have been interpreted as being epitopes on CD3ε for C3E-7034: Ser55, Glu56, Leu58, Trp59, Asn65, Ile66, Ser77, Asp78, Arg101, Gly102, Ser103, Lys104, and Pro105.

[0251]

Among these epitopes on CD3ε for C3E-7034, Arg101, Gly102, Ser103, Lys104, and Pro105 are common epitope residues on CD3ε for OKT3 and UCHT1 (Kjer-Nielsen et al., PNAS 101 (2004), p. 7675-80; and Arnett et al., PNAS 101 (2004), p. 16268-73). It has also been revealed that C3E-7034 does not interact with amino acid positions 22 to 48 in SEQ ID NO: 1, which correspond to epitopes for anti-CD3 antibodies such as I2C and H2C as described in WO2008/119565A2. Figure 41 shows interacting residues on the sequence of CD3ε. The signal sequence of CD3ε is indicated by

italicized letters, and amino acids having a distance within 4 angstroms of C3E-7034 are underlined.

[0252]

(Example 6) Preparation of humanized OKT3 scFv

6)-1 Construction of OKT3 scFv expression vector pC3E-3000

scFv of a mouse anti-CD3 monoclonal antibody OKT3 (Sgro, Toxicology 105 (1995), 23-29, Orthoclone, Janssen-Cilag) was prepared by the same approach as in Example 4)-1-1 and inserted to a pcDNA3.3-derived expression vector for animal cells. The resulting expression vector was designated as "pC3E-3000."

[0253]

6)-2 Design of humanized amino acid sequence of OKT3 scFv (C3E-3000)

On the basis of the approach described in Example 4)-2-1, the amino acid sequence of C3E-3007 serving as a humanized form of OKT3 was designed with human subgroup consensus sequences gamma 1 and kappa 4 as acceptors. Kappa 1 amino acids were introduced to some sites in consideration of the influence on immunogenicity scores and on physical properties. The amino acid sequence of the C3E-3007 light chain designed from the OKT3 heavy chain variable region shown in Figure 42 (SEQ ID NO: 36) by the replacement of glutamine at amino acid position 5 with valine, leucine at amino acid position 11 with serine, alanine at amino acid position 12 with lysine,

arginine at amino acid position 13 with lysine, methionine at amino acid position 20 with valine, lysine at amino acid position 38 with arginine, arginine at amino acid position 40 with alanine, isoleucine at amino acid position 48 with methionine, lysine at amino acid position 67 with arginine, alanine at amino acid position 68 with valine, leucine at amino acid position 70 with isoleucine, threonine at amino acid position 72 with alanine, serine at amino acid position 76 with threonine, glutamine at amino acid position 82 with glutamic acid, threonine at amino acid position 87 with arginine, serine at amino acid position 91 with threonine, threonine at amino acid position 114 with leucine, and leucine at amino acid position 115 with valine is described in Figure 43 (SEQ ID NO: 38).

[0254]

The amino acid sequence of the C3E-3007 light chain designed from the OKT3 light chain variable region shown in Figure 44 (SEQ ID NO: 37) by the replacement of valine at amino acid position 3 with glutamine, leucine at amino acid position 4 with methionine, alanine at amino acid position 9 with serine, isoleucine at amino acid position 10 with serine, methionine at amino acid position 11 with leucine, serine at amino acid position 12 with alanine, alanine at amino acid position 13 with valine, proline at amino acid position 15 with

leucine, lysine at amino acid position 18 with arginine, valine at amino acid position 19 with alanine, methionine at amino acid position 21 with isoleucine, serine at amino acid position 39 with proline, threonine at amino acid position 41 with lysine, serine at amino acid position 42 with alanine, alanine at amino acid position 59 with aspartic acid, histidine at amino acid position 60 with arginine, arginine at amino acid position 62 with serine, serine at amino acid position 69 with aspartic acid, tyrosine at amino acid position 70 with phenylalanine, serine at amino acid position 71 with threonine, glycine at amino acid position 76 with serine, methionine at amino acid position 77 with leucine, glutamic acid at amino acid position 78 with glutamine, alanine at amino acid position 82 with valine, serine at amino acid position 99 with glutamine, and leucine at amino acid position 103 with valine is described in Figure 45 (SEQ ID NO: 39).

[0255]

6)-3 Construction of humanized OKT3 scFv (C3E-3007) expression vector pC3E-3007

A DNA fragment comprising a DNA sequence of scFv containing the C3E-3007 light chain (shown in Figure 45 (SEQ ID NO: 39)) region connected to the carboxyl terminus of the C3E-3007 heavy chain (shown in Figure 43 (SEQ ID NO: 38)) via a 15-amino acid flexible

linker, and 15-base additional sequences upstream and downstream thereof was synthesized (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). A C3E-3007 expression vector containing the nucleotide sequence of Figure 46 (SEQ ID NO: 34) in ORF was constructed in the same manner as in Example 4)-3-1. The resulting expression vector was designated as "pC3E-3007."

[0256]

6)-4 Expression and purification of humanized OKT3 scFv (C3E-3007)

C3E-3007 was expressed and purified in the same manner as Example 4)-1-2. The amino acid sequence of C3E-3007 is described in Figure 47 (SEQ ID NO: 35).

[0257]

(Example 7) *In vitro* activity of humanized anti-CD3 scFv

7)-1 Study of binding activity of humanized anti-CD3 scFv (C3E-3007, C3E-7034, C3E-7035, and C3E-7036) against human CD3

7)-1-1 Study of binding activity of humanized anti-CD3 scFv (C3E-3007, C3E-7034, C3E-7035, and C3E-7036) to human CD3 by flow cytometry

Commercially available human PBMC (Cellular Technology Ltd. (CTL)) was adjusted to an appropriate concentration with PBS containing 5% FBS. LIVE/DEAD Fixable Near-IR Dead Cell Stain Kit (Thermo Fisher Scientific Inc.) and an anti-CD19 antibody (Beckman

Coulter Inc.) were added to the cells, which were then left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS, then adjusted to a concentration of 1×10^6 cells/mL with PBS containing 5% FBS, added at a concentration of 100 μL/well to a 96-well U-bottomed microplate, and centrifuged to remove a supernatant. Each humanized anti-CD3 scFv (C3E-3007, C3E-7034, C3E-7035, and C3E-7036) diluted with PBS containing 5% FBS was added at a concentration of 100 μL/well, and the plate was left standing at 4°C for 60 minutes. The cells were washed twice with PBS containing 5% FBS. Then, Penta-His Alexa Fluor 488 (Qiagen N.V.) diluted with PBS containing 5% FBS was added at a concentration of 30 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (FACSCanto(TM) II; Becton, Dickinson and Company). The data was analyzed using Flowjo (Tree Star Inc.). The mean fluorescence intensity (MFI) of Alexa Fluor 488 in a fraction free of dead cells and CD19-positive cells was calculated. The MFI value of the scFv-unsupplemented sample was subtracted from the MFI value of the scFv-supplemented sample to calculate a relative value of MFI (rMFI). As shown in Figure 48, the humanized anti-CD3 scFvs were found to bind to human CD3.

[0258]

7)-1-2 Study of binding activity of humanized anti-CD3 scFvs (C3E-3007, C3E-7034, C3E-7035, and C3E-7036) to human CD3 by SPR

The affinity of each humanized anti-CD3 scFv (C3E-3007, C3E-7034, C3E-7035, and C3E-7036) for CD3 was determined by the surface plasmon resonance method using BIAcore T-200 (GE Healthcare Bio-Sciences Corp.). Five different concentrations of the scFv were injected into CD3 immobilized on a sensor chip. Rmax was estimated from the resulting response, and the antibody concentration that reached 1/2 thereof was defined as the dissociation constant of the scFv for CD3. As a result, the dissociation constants of these scFvs for CD3 were 400, 4.5, 22, and 25 nM, respectively.

[0259]

7)-2 A study of the binding activity of humanized antibody CD3 scFv (C3E-3007, C3E-7034, and C3E-7036) with cynomolgus monkey CD3

7)-2-1 Preparation of cynomolgus monkey PBMC

PBMC was collected from the blood of a cynomolgus monkey according to the standard method using SepMate (StemCell Technologies Inc.) and Lymphocyte Separation Solution (Nacalai Tesque Inc.).

[0260]

7)-2-2 Study of binding activity of humanized anti-CD3 scFvs (C3E-3007, C3E-7034, C3E-7035, and

C3E-7036) to cynomolgus monkey CD3 by flow cytometry

The cynomolgus monkey PBMC obtained in Example 7)-2-1 was adjusted to an appropriate concentration with PBS containing 5% FBS, and stained and analyzed in the same manner as Example 7)-1-1. As shown in Figure 49, the humanized anti-CD3 scFvs (C3E-7034, C3E-7035, and C3E-7036) were found to bind to cynomolgus monkey CD3.

[0261]

7)-3 T cell activation of humanized anti-CD3 scFvs (C3E-3007 and, C3E-7034)

Human peripheral blood mononuclear cells (PBMC) were isolated from the fresh buffy coats of random donors by the density gradient centrifugation method using Lympholyte-H (Cedarlane). Each humanized anti-CD3 scFv (C3E-3007 and C3E-7034) diluted to 100 nM with LR10 (RPMI1640 containing 10% ultra low IgG FBS (Thermo Fisher Scientific Inc.)) and the same concentration of Anti-His antibody (Qiagen N.V.) were mixed in the same amounts. The human or monkey PBMC was adjusted to 2×10^5 cells with LR10, and mixed with the mixture of the humanized anti-CD3 scFv and Anti-His antibody, in the same amounts in a 96-well U-bottomed microplate, and cultured at 37°C for 24 hours under 5% CO_2 conditions. After completion of the reaction, the reaction solution was centrifuged, and a sorter buffer (HBSS(-) (Thermo Fisher Scientific Inc.), 0.1% BSA (Sigma-Aldrich Corp.), and

0.1% sodium azide (Sigma-Aldrich Corp.)) were added. After centrifugation, LIVE/DEAD Fixable Near-IR Dead Cell Stain Kit (Thermo Fisher Scientific Inc.) was added to the cells, which were then left standing at 4°C for 20 minutes. The cells were washed with a sorter buffer. Then, a PE-labeled anti-CD69 antibody (Becton, Dickinson and Company) and an FITC-labeled anti-CD8 antibody (Becton, Dickinson and Company) diluted with a sorter buffer were added to the cells, which were then left standing at 4°C for 20 minutes. The cells were washed with a sorter buffer and then resuspended in PBS (Wako Pure Chemicals Industries, Ltd.) containing 1% paraformaldehyde, followed by detection using a flow cytometer (FACSCanto II; Becton, Dickinson and Company). The data was analyzed using Flowjo (Tree Star Inc.). The ratio of a fraction highly expressing CD8 and highly expressing PE to a fraction free from dead cells was calculated as percentage with respect to the population (% of parents). As shown in Figure 50, the humanized anti-CD3 scFvs were found to activate cells highly expressing human and monkey CD8.

[0262]

7)-4 Comparison of the binding activity of CDR modified humanized anti-CD3 scFv with human and cynomolgus monkey CD3 by flow cytometry

The human PBMC obtained in Example 7)-1-1 and the cynomolgus monkey PBMC obtained in Example 7)-2-

1 were each adjusted to an appropriate concentration with PBS containing 5% FBS, and stained and analyzed in the same manner as Example 7)-1-1. As shown in Figure 106, the CDR modified humanized anti-CD3 scFvs were confirmed to have binding activity with both human and monkey CD3.

[0263]

(Example 8) Preparation of humanized anti-TROP2 scFv

8)-1 Construction of HT1-11 scFv expression vector pHT1-11scFv

A DNA fragment comprising a DNA sequence encoding the amino acids of HT1-11 scFv shown in Figure 51 (SEQ ID NO: 41) was synthesized (GeneArt Gene Synthesis Service/Thermo Fisher Scientific Inc.). The synthesized DNA fragment was inserted into a vector derived from pcDNA-3.3TOPO (Thermo Fisher Scientific Inc.) using In-Fusion HD PCR cloning kit (Clontech Laboratories, Inc.) to construct a humanized anti-TROP2 scFv expression vector pHT1-11scFv containing the nucleotide sequence shown in Figure 52 (SEQ ID NO: 40) in ORF.

[0284]

8)-2 Expression and purification of HT1-11 scFv (HT1-11 scFv)

HT1-11 scFv was expressed and purified in the same manner as Example 4)-1-2.

[0265]

(Example 9) Evaluation of binding activity of

humanized anti-TROP2 scFv (HT1-11 scFv) against human TROP2 by flow cytometry

A pharyngeal squamous cell cancer cell line FaDu (ATCC) or a pancreatic cancer cell line HPAF-II (ATCC) was adjusted to an appropriate concentration with PBS containing 5% FBS. LIVE/DEAD Fixable Near-IR Dead Cell Stain Kit was added to the cells, which were then left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS, then adjusted to a concentration of 1×10^6 cells/mL with PBS containing 5% FBS, added at a concentration of 100 μL/well to a 96-well U-bottomed microplate, and centrifuged to remove a supernatant. The humanized anti-TROP2 scFv (HT1-11 scFv) diluted with PBS containing 5% FBS was added at a concentration of 100 μL/well, and the plate was left standing at 4°C for 60 minutes. The cells were washed twice with PBS containing 5% FBS. Then, Penta-His Alexa Fluor 488 diluted with PBS containing 5% FBS was added at a concentration of 30 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (FACSCanto(TM) II). The data was analyzed using Flowjo. The mean fluorescence intensity (MFI) of Alexa Fluor 488 in a fraction free of dead cells was calculated. The MFI value of the antibody-unsupplemented sample was subtracted from

the MFI value of the scFv-supplemented sample to calculate a relative value of MFI (rMFI). As shown in Figure 53, the humanized anti-TROP2 scFv was found to bind to human TROP2.

[0266]

(Example 10) Preparation of anti-TROP2-CD3 bispecific molecules

10)-1 Construction of an anti-TROP2-CD3 bispecific molecule expression vector

10)-1-1 Construction of HT1-11 scFv/C3E-7034 bispecific molecule (T2C-0001) expression vector

An insert DNA fragment was obtained by PCR using the pHT1-11 scFv prepared in Example 8)-1 as a template and using primers designed to add the nucleotide sequences of HT1-11 scFv and a portion of a human antibody heavy chain signal sequence to the 5' side and to add the nucleotide sequence of a linker to connect scFvs to the 3' side. Also, a vector DNA fragment containing the entire vector region including anti-CD3 scFv DNA was obtained by PCR using the expression vector pC3E-7034 prepared in Example 4)-3-1 as a template and using primers encoding a signal sequence and the amino-terminal sequence of the anti-CD3 scFv. These DNA fragments were ligated using the In-Fusion HD cloning kit (Clontech Laboratories, Inc.) to prepare an anti-TROP2-anti-CD3 bispecific molecule expression vector pT2C-0001 containing the nucleotide sequence of Figure 54 (SEQ

ID NO: 42) in ORF.

[0267]

10)-1-2 Construction of an HT1-11 scFv/C3E-3007 bispecific molecule (T2C-0003) expression vector

An anti-TROP2-CD3 bispecific molecule expression vector containing the nucleotide sequence of Figure 55 (SEQ ID NO: 44) in ORF was constructed in the same manner as Example 10)-1-1 except that pC3E-3007 was used as a template for preparing the vector fragment. The resulting expression vector was designated as "pT2C-0003."

[0268]

10)-1-3 Construction of an HT1-11 scFv/C3E-7035 bispecific molecule (T2C-0005) expression vector

An anti-TROP2-CD3 bispecific molecule expression vector containing the nucleotide sequence of Figure 56 (SEQ ID NO: 46) in ORF was constructed in the same manner as Example 10)-1-1 except that pC3E-7035 was used as a template for preparing the vector fragment. The resulting expression vector was designated as "pT2C-0005."

[0269]

10)-1-4 Construction of an HT1-11 scFv/C3E-7036 bispecific molecule (T2C-0006) expression vector

An anti-TROP2-CD3 bispecific molecule expression vector containing the nucleotide sequence of Figure 57 (SEQ ID NO: 48) in ORF was constructed in the same manner as Example 10)-1-1 except that

pC3E-7036 was used as a template for preparing the vector fragment. The resulting expression vector was designated as "pT2C-0006."

[0270]

10)-2 Expression and purification of anti-TROP2-CD3 bispecific molecules

T2C-0001, T2C-0003, T2C-0005, and T2C-0006 were expressed and purified in the same manner as Example 4)-1-2. The amino acid sequence of T2C-0001 is described in Figure 58 (SEQ ID NO: 43). The amino acid sequence of T2C-0003 is described in Figure 59 (SEQ ID NO: 45). The amino acid sequence of T2C-0005 is described in Figure 60 (SEQ ID NO: 47). The amino acid sequence of T2C-0006 is described in Figure 61 (SEQ ID NO: 49).

[0271]

(Example 11) Evaluation of *in vitro* activity of anti-TROP2-CD3 bispecific molecules

11)-1 Binding activity evaluation by SPR

11)-1-1 Binding activity of an anti-TROP2-CD3 bispecific molecule to TROP2

The bispecific molecule was assayed for its binding to TROP2 using BIAcore 3000 (GE Healthcare Bio-Sciences Corp.) by the capture method, which involves capturing the antigen by an anti-human IgG antibody and assaying the bispecific molecule as an analyte. The antigen used was recombinant human TROP-2/human IgG Fc fused form (R&D Systems, Inc.).

Approximately 2000 RU of the anti-human IgG(Fc) antibody (Human Antibody Capture Kit, GE Healthcare Bio-Sciences Corp.) was covalently bound to a sensor chip CM5 (GE Healthcare Bio-Sciences Corp.) by the amine coupling method. Similarly, this antibody was immobilized onto a reference cell. The running buffer used was HBS-P (10 mM HEPES (pH 7.4), 0.15 M NaCl, and 0.005% Surfactant P20). The bispecific molecule was prepared at a 2-fold dilution ratio from 200 nM to 1 nM. A 1 μg/ml solution of the antigen was added onto the anti-human IgG(Fc) antibody-immobilized chip for approximately 30 seconds. Then, each concentration of the bispecific molecule was added at a flow rate of 30 μl/min for 300 seconds. Subsequently, the dissociation phase was monitored for 600 seconds. A 3 M magnesium chloride solution was added as a regenerating solution for 30 seconds. The data was analyzed using the 1:1 binding model of analytical software (BIAevaluation software, version 4.1.1) to calculate an association rate constant (ka), a dissociation rate constant (kd), and a dissociation constant (KD; KD = kd/ka).

[0272]

11)-1-2 Binding activity of an anti-TROP2-CD3 bispecific molecule to a human CD3εγ single-chain antigen

The bispecific molecule was assayed for its binding to the CD3εγ antigen using BIAcore 3000 (GE

Healthcare Bio-Sciences Corp.) by a method which involves immobilizing the antigen and assaying the antibody as an analyte. The antigen used was the human CD3εγ single-chain antigen prepared in Example 2)-2-1. Approximately 100 RU of the antigen was covalently bound to a sensor chip CM5 (GE Healthcare Bio-Sciences Corp.) by the amine coupling method. Immobilization treatment was performed without the addition of an antigenic protein as a reference cell. The running buffer used was HBS-P (10 mM HEPES (pH 7.4), 0.15 M NaCl, and 0.005% Surfactant P20). The bispecific molecule was prepared at a 2-fold dilution ratio from 1 μM (highest concentration) to 4 nM or at a 2-fold dilution ration from 200 nM to 1 nM. Each concentration of the bispecific molecule was added to the antigen-immobilized chip at a flow rate of 10 μl/min for 25 minutes, and the amount of the bispecific molecule bound thereto was monitored. A 10 mM glycine-hydrochloric acid solution (pH 1.5) was added as a regenerating solution for 30 seconds. The data was analyzed using analytical software (BIAevaluation software, version 4.1.1) to calculate a dissociation constant KD from the amount of the bispecific molecule bound at each concentration. The results are shown in Tables 2 and 3.

[0273]

[Table 2]

	Name	CD3εγ KD (nM)
1	T2C-0001	13.9
2	T2C-0003	171
3	T2C-0005	126
4	T2C-0006	171

[0274]

[Table 3]

	Name	TROP2 KD (nM)
1	T2C-0001	12.8
2	T2C-0003	6.7
3	T2C-0005	11.9
4	T2C-0006	9.3

[0275]

11)-2 Binding activity evaluation by flow cytometry

11)-2-1 Binding activity of an anti-TROP2-CD3 bispecific molecule to TROP2

The same cancer cell lines as those in Example 9 were used, and stained and analyzed in the same manner as Example 9. As shown in Figure 62, the anti-TROP2-CD3 bispecific molecules were found to bind to TROP2.

[0276]

11)-2-2 Binding activity of an anti-TROP2-CD3

bispecific molecule to a human CD3εγ single-chain antigen

Cells were stained and analyzed in the same manner as Example 7)-1-1. As shown in Figure 63, the anti-TROP2-CD3 bispecific molecules were found to bind to the human CD3εγ single-chain antigen.

[0277]

11)-2-3 Binding activity of an anti-TROP2-CD3 bispecific molecule to a cynomolgus monkey CD3 antigen

The cynomolgus monkey PBMC obtained in Example 7)-2-1 was adjusted to an appropriate concentration with PBS containing 5% FBS, and stained and analyzed in the same manner as Example 7)-1-1. As shown in Figure 64, the anti-TROP2-CD3 bispecific molecules (T2C-0001, T2C-0005, and T2C-0006) were found to bind to the cynomolgus monkey CD3 antigen.

[0278]

11)-3 Evaluation of the cytotoxic activity of anti-TROP2-CD3 bispecific molecules

11)-3-1 Expression analysis of TROP2 in target cells

Pharyngeal squamous cell cancer cell line FaDu (ATCC), pancreatic cancer cell line HPAF-II (ATCC), or human lung cancer cell line Calu-6 cells were adjusted to an appropriate concentration with PBS containing 5% FBS. LIVE/DEAD Fixable Dead Cell Stain Kit (Thermo Fisher Scientific Inc.) was added to the

cells, which were then left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS, then adjusted to a concentration of 2 × 10^6 cells/mL with PBS containing 5% FBS, inoculated at a concentration of 100 μL/well to a 96-well U-bottomed microplate, and centrifuged to remove a supernatant. Anti-TROP2 Alexa Fluor 488 antibody (Affymetrix eBioscience) and Isotype Control antibody (Affymetrix eBioscience) diluted with PBS containing 5% FBS were added at a concentration of 25 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (Cytomics FC500, Beckman Coulter Inc.). The data was analyzed using Flowjo (Tree Star Inc.). The geometric average fluorescence intensity (geometric MFI) of Alexa Fluor 488 in a fraction free from dead cells was calculated. As shown in Figures 65A, 65B, and 65C, the expression of TROP2 was observed in the FaDu and HPAF-II cells, but was not observed in the Calu-6 cells.

[0279]

11)-3-2 Preparation of target cells

FaDu, HPAF-II, or Calu-6 cells were adjusted to a concentration of 2 × 10^6 cells/mL with an RPMI1640 medium (Thermo Fisher Scientific Inc.) containing 10% FBS. To each cell line, 100 μL of Chromium-51

Radionuclide (PerkinElmer, Inc.) was added per mL of the cell suspension, and the cells were cultured at 37°C for 2 hours under 5% CO_2 conditions. The cells were washed twice with an RPMI1640 medium containing 10% FBS, then resuspended to 2×10^5 cells/mL in an RPMI1640 medium containing 10% FBS, and used as target cells.

[0280]

11)-3-3 Preparation of effector cells

Commercially available frozen PBMC (Cellular Technology Limited) was thawed at 37°C, transferred to a solution of an RPMI1640 medium containing 10% FBS supplemented with Anti-aggregate Wash reagent (Cellular Technology Limited), washed twice, then adjusted to 1×10^6 cells/mL with an RPMI1640 medium containing 10% FBS, and used as effector cells.

[0281]

11)-3-4 Cytotoxicity assay

The FaDu cells, the HPAF-II cells, or the Calu-6 cells obtained in Example 11)-3-2 were added at a concentration of 50 μL/well to a 96-well U-bottomed microplate. Each anti-TROP2-CD3 bispecific molecule adjusted to varying concentrations was added at a concentration of 50 μL/well. The effector cells prepared in Example 11)-3-1-3 were added at a concentration of 100 μL/well. After centrifugation at room temperature at 1000 rpm for 1 minute, the cells were cultured at 37°C for 20 to 24 hours under

5% CO_2 conditions. A 50 μL aliquot of the supernatant was recovered into LumaPlate (PerkinElmer, Inc.) and dried at 50°C for approximately 2 hours, followed by measurement using a plate reader (TopCount; PerkinElmer, Inc.). The percentage of cells lysed was calculated according to the following expression:

Percentage of cells lysed (%) = (A - B) / (C - B) × 100

A: Sample well count

B: Average background count (antibody-unsupplemented wells) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. The other procedures were the same as in the case of the sample well.

C: Average of maximum release count (wells containing target cells lysed in a surfactant) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. 100 μL of the surfactant was added, and the 50 μL aliquot was transferred to LumaPlate, as with the sample well, and assayed.

As shown in Figures 66A, 66B, and 66C, these anti-TROP2-CD3 bispecific molecules exhibited cytotoxic activity against the FaDu cells and the HPAF-II cells). On the other hand, these bispecific molecules exhibited no cytotoxic activity in the Calu-6 cells.[0282]

(Example 12) Preparation of anti-Axl- CD3 bispecific molecules

12)-1 Construction of anti-Axl- CD3 bispecific

molecule expression vector

12)-1-1 Construction of 11D5-T3 scFv/C3E-7034 bispecific molecule (AXC-0001) expression vector

The amino acid sequence of an anti-Axl single chain antibody 11D5-T3 scFv was designed by connecting the N-terminally glycine-added sequence of h#11D5-T3H (described in Figure 12 in the specification of European Patent Application Publication No. 2270053) and h#11D5-T3L (described in Figure 6 in the specification of European Patent Application Publication No. 2270053) via a polypeptide linker consisting of a sequence having 3 repeats of (GGGGS). A nucleotide sequence encoding this amino acid sequence was synthesized (GENEART, Thermo Fisher Scientific). An insert DNA fragment was obtained by PCR using this nucleotide sequence as a template and using primers designed to add the nucleotide sequence of a portion of a human antibody heavy chain signal sequence to the 5' end and to add the nucleotide sequence of a linker to connect scFvs to the 3' end. Also, a vector DNA fragment was obtained by the PCR amplification of the whole vector region including CD3 scFv DNA using the expression vector pC3E-7034 prepared in Example 4)-3-1 as a template and using primers consisting of a nucleotide sequence encoding a human antibody heavy chain signal sequence and the CD3 scFv. The DNA fragments ligated using In-Fusion HD cloning kit (Clontech Laboratories,

Inc.) resulted in anti-AXL-anti-CD3 bispecific molecule expression vector pAXC-0001 containing the nucleotide sequence shown in Figure 97 (SEQ ID NO: 89) in ORF.[0283]

12)-1-2 Construction of 11D5-T3 scFv/C3E-7036 bispecific molecule (AXC-0002) expression vector

An anti-Axl- CD3 bispecific molecule expression vector containing the nucleotide sequence shown in Figure 99 (SEQ ID NO: 91) in ORF was constructed in the same manner as Example 10)-1-1 except that pC3E-7036 was used as a template for preparing the vector fragment. The resulting expression vector was designated as "pAXC-0002."

[0284]

12)-2 Expression and purification of anti-AxL-CD3 bispecific molecules

AXC-0001 and AXC-0002 were expressed and purified in the same manner as Example 4)-1-2. The amino acid sequence of AXC-0001 is described in Figure 98 (SEQ ID NO: 90). The amino acid sequence of AXC-0002 is described in Figure 100 (SEQ ID NO: 92).

[0285]

(Example 13) Evaluation of *in vitro* activity of anti-Axl- CD3 bispecific molecules

13)-1 Expression analysis of Axl in target cells

Human lung cancer cell line A549 (ATCC), human pancreatic cancer cell line PANC-1 (ATCC) or MIA

PaCa-2 (ATCC), human myeloma cell line U266B1(ATCC), or mantle cell lymphoma cell line Jeko-1 (ATCC) was adjusted to an appropriate concentration with PBS containing 5% FBS. LIVE/DEAD Fixable Dead Cell Stain Kit (Thermo Fisher Scientific Inc.) was added to the cells, which was then left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS, then adjusted to a concentration of 2×10^6 cells/mL with PBS containing 5% FBS, inoculated at a concentration of 100 μL/well in a 96-well U-bottomed microplate, and centrifuged to remove the supernatant. Anti-Axl antibody (RD Systems, Inc.) and Isotype Control antibody (RD Systems, Inc.) diluted with PBS containing 5% FBS were added at a concentration of 25 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS. Then, Alexa Fluor 488 anti-mouse IgG antibody (Thermo Fisher Scientific Inc.) diluted with PBS containing 5% FBS was added at a concentration of 25 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (Cytomics FC500, Beckman Coulter Inc.). The data was analyzed using Flowjo (Tree Star Inc.). The geometric average fluorescence intensity (geometric MFI) of Alexa Fluor 488 in a fraction free of dead cells was calculated.

As shown in Figures 107A, 107B, 107C, 107D, and 107E, the expression of Axl was observed in A549, PANC-1, and MIA PaCa-2, but was not observed in U266B1 and Jeko-1.

[0286]

13)-2 Preparation of target cells

A549, PANC-1, MIA PaCa-2, U266B1, and Jeko-1 were each adjusted to a concentration of 2×10^6 cells/mL with an RPMI1640 medium (Thermo Fisher Scientific Inc.) containing 10% FBS. To each cell line, 100 μL of Chromium-51 Radionuclide (PerkinElmer, Inc.) was added per mL of the cell suspension, and the cells were cultured at 37°C for 2 hours under 5% CO_2 conditions. The cells were washed twice with an RPMI1640 medium containing 10% FBS, then resuspended to 2×10^5 cells/mL in an RPMI1640 medium containing 10% FBS, and used as target cells.

13)-3 Preparation of effector cells

Commercially available frozen PBMC (Cellular Technology Limited) was thawed at 37°C, transferred to a solution of an RPMI1640 medium containing 10% FBS supplemented with Anti-aggregate Wash reagent (Cellular Technology Limited), washed twice, then adjusted to 1×10^6 cells/mL with an RPMI1640 medium containing 10% FBS, and used as effector cells.

[0287]

13)-4 Cytotoxicity assay

The A549, PANC-1, MIA PaCa-2, U266B1, or Jeko-1 cells obtained in Example 13)-2 were added at a concentration of 50 μL/well to a 96-well U-bottomed microplate. Each anti-Axl CD3 bispecific molecule adjusted to varying concentrations was added at a concentration of 50 μL/well. The effector cells prepared in Example 13)-3 were added at a concentration of 100 μL/well. After centrifugation at room temperature at 1000 rpm for 1 minute, the cells were cultured at 37°C for 20 to 24 hours under 5% CO_2 conditions. A 50 μL aliquot of the supernatant was transferred to a LumaPlate (PerkinElmer, Inc.) and dried at 50°C for approximately 2 hours, followed by measurement using a plate reader (TopCount; PerkinElmer, Inc.). The percentage of cells lysed was calculated according to the following equation:

Percentage of cells lysed (%) = (A - B) / (C - B) × 100

A: Sample well count

B: Average background count (antibody-unsupplemented wells) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. The other procedures were the same as in the case of the sample well.

C: Average of maximum release count (wells containing target cells lysed in a surfactant) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. 100 μL of the surfactant was added, and the 50 μL aliquot was transferred to LumaPlate, as with

the sample well, and assayed.

[0288]

As shown in Figures 108A, 108B, 108C, 108D, and 108E, these anti-Axl CD3 bispecific molecules exhibited cytotoxic activity against A549, PANC-1, and MIA PaCa-2. However, these bispecific molecules exhibited no cytotoxic activity against U266B1 or Jeko-1.

[0289]

(Example 14) Preparation of anti-HLA-A2/MAGEC1 -CD3 bispecific molecule expression vector

14)-1 Construction of anti-HLA-A2/MAGEC1 -CD3 bispecific molecule expression vector

14)-1-1 Construction of MAG-032 scFv/C3E-7034 bispecific molecule (MGC-0001) expression vector

MAG-032 scFv specifically binding to HLA-A2/MAGEC1 was obtained from a human antibody phage library. An insert DNA fragment containing a nucleotide sequence encoding the amino acid sequence of MAG-032 scFv was obtained by PCR using the nucleotide sequence encoding the amino acid sequence of MAG-032 scFv as a template and using primers designed to add a nucleotide sequence encoding a human antibody heavy chain signal sequence to the 5' end, and to add a nucleotide sequence encoding a linker to connect scFvs and a portion of C3E-7034 to the 3' end. Also, a vector DNA fragment was obtained by the PCR amplification of the entire vector region

including anti-CD3 scFv DNA using the expression vector pC3E-7034 prepared in Example 4)-3-1 as a template and using primers consisting of a nucleotide sequence encoding a human antibody heavy chain signal sequence and the amino-terminal sequence of the anti-CD3 scFv. These DNA fragments were ligated using an In-Fusion HD cloning kit (Clontech Laboratories, Inc.) to prepare an anti-HLA-A2/MAGEC1-anti-CD3 bispecific molecule expression vector pMGC-0001 containing the nucleotide sequence shown in Figure 101 (SEQ ID NO: 93) in ORF.

[0290]

14)-1-2 Construction of MAG-032 scFv/C3E-7036 bispecific molecule (MGC-0002) expression vector

An anti-HLA-A2/MAGEC1 -CD3 bispecific molecule expression vector containing the nucleotide sequence shown in Figure 103 (SEQ ID NO: 95) in ORFwas constructed in the same manner as Example 14)-1-1 except that pC3E-7036 was used as a template for preparing the vector fragment. The resulting expression vector was designated as "pMGC-0002."

[0291]

14)-2 Expression and purification of anti-HLA-A2/MAGEC1 -CD3 bispecific molecules

MGC-0001 and MGC-0002 were expressed and purified in the same manner as Example 4)-1-2. The amino acid sequence of MGC-0001 is listed in Figure 102 (SEQ ID NO: 94). The amino acid sequence of MGC-

0002 is listed in Figure 104 (SEQ ID NO: 96).

(Example 15) Evaluation of *in vitro* activity of anti-HLA-A2/MAGEC1 -CD3 bispecific molecules

15)-1 Expression analysis of HLA-A2/MAGEC1 in target cells

Human lymphoblast fusion cell line T2 (ATCC) cells were adjusted to an appropriate concentration with an AIM-V medium (Thermo Fisher Scientific Inc.) containing 20% FBS. MAGEC1 peptide of Figure 106 (SEQ ID NO: 97) (Sigma Genosys) or DMSO was added to the cells, which were then incubated at 37°C for 4 hours. The cells were washed twice with an AIM-V medium containing 20% FBS and then adjusted to an appropriate concentration with PBS containing 5% FBS. LIVE/DEAD Fixable Dead Cell Stain Kit (Thermo Fisher Scientific Inc.) was added to the cells, which were then left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS, then adjusted to a concentration of 2×10^6 cells/mL with PBS containing 5% FBS, inoculated at a concentration of 100 μL/well to a 96-well U-bottomed microplate, and centrifuged to remove a supernatant. The anti-HLA-A2/MAGEC1 antibody (MAG032 scFv) diluted with PBS containing 5% FBS was added at a concentration of 25 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS. Then, Penta-His Alexa Fluor 488

(Qiagen N.V.) diluted with PBS containing 5% FBS was added at a concentration of 25 μL/well, and the plate was left standing at 4°C for 30 minutes. The cells were washed twice with PBS containing 5% FBS and then resuspended in PBS containing 5% FBS, followed by detection using a flow cytometer (Cytomics FC500, Beckman Coulter Inc.). The data was analyzed using Flowjo (Tree Star Inc.). The geometric average fluorescence intensity (geometric MFI) of Alexa Fluor 488 in a fraction free of dead cells was calculated. As shown in Figures 109A and 109B, expression of HLA-A2/MAGEC1 was observed in the T2 cells supplemented with the MAGEC1 peptide, but was not observed in the T2 cells supplemented with DMSO.

[0292]

15)-2 Preparation of target cells

T2 cells were adjusted to an appropriate concentration with an AIM-V medium (Thermo Fisher Scientific Inc.) containing 20% FBS. MAGEC1 peptide or DMSO was added to the cells, which were then incubated at 37°C for 4 hours. The cells were adjusted to a concentration of 2×10^6 cells/mL with an RPMI1640 medium (Thermo Fisher Scientific Inc.) containing 10% FBS. To this cell line, 100 μL of Chromium-51 Radionuclide (PerkinElmer, Inc.) was added per mL of the cell suspension, and the cells were cultured at 37°C for 2 hours under 5% CO_2 conditions. The cells were washed twice with an

RPMI1640 medium containing 10% FBS, then resuspended to 2 × 10^5 cells/mL in an RPMI1640 medium containing 10% FBS, and used as target cells.

15)-3 Preparation of effector cells

Commercially available frozen PBMC (Cellular Technology Limited) was thawed at 37°C, transferred to a solution of an RPMI1640 medium containing 10% FBS supplemented with Anti-aggregate Wash reagent (Cellular Technology Limited), washed twice, then adjusted to 1 × 10^6 cells/mL with an RPMI1640 medium containing 10% FBS, and used as effector cells.

[0293]

15)-4 Cytotoxicity assay

The T2 cells obtained in Example 15)-2 were added at a concentration of 50 μL/well to a 96-well U-bottomed microplate. Each anti-HLA-A2/MAGEC1-CD3 bispecific molecule adjusted to varying concentrations was added at a concentration of 50 μL/well. The effector cells prepared in Example 15)-3 were added at a concentration of 100 μL/well. After centrifugation at room temperature at 1000 rpm for 1 minute, the cells were cultured at 37°C for 20 to 24 hours under 5% CO_2 conditions. A 50 μL aliquot of the supernatant was recovered in a LumaPlate (PerkinElmer, Inc.) and dried at 50°C for approximately 2 hours, followed by measurement using a plate reader (TopCount; PerkinElmer, Inc.). The percentage of

cells lysed was calculated according to the following equation:

Percentage of cells lysed (%) = (A - B) / (C - B) × 100

A: Sample well count

B: Average background count (antibody-unsupplemented wells) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. The other procedures were the same as in the case of the sample well.

C: Average of maximum release count (wells containing target cells lysed in a surfactant) (n = 3). 50 μL of a medium for assay was added instead of adding the antibody. 100 μL of the surfactant was added, and the 50 μL aliquot was transferred to LumaPlate, as with the sample well, and assayed.

[0294]

As shown in Figures 110A and 110B, these anti-HLA-A2/MAGEC1-CD3 bispecific molecules exhibited cytotoxic activity against the T2 cells supplemented with the MAGEC1 peptide. On the other hand, these bispecific molecules exhibited no cytotoxic activity in the T2 cells supplemented with DMSO.

[Industrial Applicability]

[0295]

The humanized anti-CD3 antibody of the present invention binds to human CD3 and also binds to cynomolgus monkey CD3. Therefore, the humanized anti-

CD3 antibody of the present invention can be used advantageously in nonclinical trials for the development of drugs.

[0296]

[Sequence Listing Free Text]

SEQ ID NO: 1: Amino acid sequence of human CD3ε

SEQ ID NO: 2: Amino acid sequence of human CD3δ

SEQ ID NO: 3: Amino acid sequence of human CD3γ

SEQ ID NO: 4: Nucleotide sequence encoding human CD3εγ single-chain antigen

SEQ ID NO: 5: Amino acid sequence of His-scCD3 antigen

SEQ ID NO: 6: Nucleotide sequence encoding the heavy chain variable region of C3-147

SEQ ID NO: 7: (C3-147_VH AA): Amino sequence of the heavy chain variable region of C3-147

SEQ ID NO: 8: (C3-147_VL DNA): Nucleotide sequence encoding the light chain variable region of C3-147

SEQ ID NO: 9: (C3-147_VL AA): Amino sequence of the light chain variable region of C3-147

SEQ ID NO: 10: (G4S linker sense):

SEQ ID NO: 11: (G4S linker antisense):

SEQ ID NO: 12: (C3E-7000_VH AA): Amino acid sequence of the heavy chain variable region in C3E-7000

SEQ ID NO: 13: (C3E-7000_VL AA): Amino acid sequence of the light chain variable region in C3E-7000

SEQ ID NO: 14: (C3E-7000 ORF): Nucleotide sequence encoding C3E-7000

SEQ ID NO: 15: (C3E-7000 AA): Amino acid sequence in C3E-7000

SEQ ID NO: 16: (C3E-7034_VH AA): Amino acid sequence of the heavy chain variable region of C3E-7034

SEQ ID NO: 17: Amino acid sequence of the light chain variable region of C3E-7034

SEQ ID NO: 18: (C3E-7034 ORF): Nucleotide sequence encoding C3E-7034

SEQ ID NO: 19: (C3E_7034 AA): Amino acid sequence of C3E-7034

SEQ ID NO: 20: (C3E-7035_VL AA): Amino acid sequence of the light chain variable region of C3E-7035

SEQ ID NO: 21: (C3E-7035 ORF): Nucleotide sequence encoding C3E-7035

SEQ ID NO: 22: (C3E_7035 AA): Amino acid sequence of C3E-7035

SEQ ID NO: 23: (C3E-7036_VL_AA): Amino acid sequence of the light chain variable region of C3E-7036

SEQ ID NO: 24: (C3E-7036 ORF): Nucleotide sequence encoding C3E-7036

SEQ ID NO: 25: (C3E_7036 AA): Amino acid sequence of C3E-7036

SEQ ID NO: 26: (7000_CDR-H1): Amino acid sequence of CDR-H1 in C3E-7000 series

SEQ ID NO: 27: (7000_CDR-H2): Amino acid sequence of CDR-H2 in C3E-7000 series

SEQ ID NO: 28: (7000_CDR-H3): Amino acid sequence of CDR-H3 in C3E-7000 series

SEQ ID NO: 29: (7000_CDR-L1): Amino acid sequence of CDR-L1 in C3E-7000 series

SEQ ID NO: 30: (7000_CDR-L2): Amino acid sequence of CDR-L2 in C3E-7000 series

SEQ ID NO: 31: (7000_CDR-L3): Amino acid sequence of CDR-L3 in C3E-7000 series

SEQ ID NO: 32: (C3E-3000 ORF): Nucleotide sequence encoding OKT3 scFv

SEQ ID NO: 33: (C3E-3000 AA): Amino acid sequence of OKT3 scFv

SEQ ID NO: 34: (C3E-3007 ORF): Nucleotide sequence encoding C3E-3007 scFv

SEQ ID NO: 35: (C3E-3007 AA): Amino acid sequence of C3E-3007 scFv

SEQ ID NO: 36: (C3E-3000_VH AA): Amino acid sequence of the heavy chain variable region of OKT3

SEQ ID NO: 37: (C3E-3000_VL AA): Amino acid sequence of the light chain variable region of OKT3

SEQ ID NO: 38: (C3E-3007_VH AA): Amino acid sequence of the heavy chain variable region of C3E-3007

SEQ ID NO: 39: (C3E-3007_VL AA): Amino acid sequence of the light chain variable region of C3E-3007

SEQ ID NO: 40: (HT1-11 ORF): Nucleotide sequence encoding HT1-11 scFv

SEQ ID NO: 41: (HT1-11 AA): Amino acid sequence of HT1-11 scFv

SEQ ID NO: 42: (T2C-0001 ORF): ORF nucleotide sequence encoding T2C-0001

SEQ ID NO: 43: (T2C-0001 AA): Amino acid sequence of T2C-0001

SEQ ID NO: 44: (T2C-0003 ORF): ORF nucleotide sequence encoding T2C-0003

SEQ ID NO: 45: (T2C-0003 AA): Amino acid sequence of T2C-0003

SEQ ID NO: 46: (T2C-0005 ORF): ORF nucleotide sequence encoding T2C-0005

SEQ ID NO: 47: (T2C-0005 AA): Amino acid sequence of T2C-0005

SEQ ID NO: 48: (T2C-0006 ORF): ORF nucleotide sequence encoding T2C-0006

SEQ ID NO: 49: (T2C-0006 AA): Amino acid sequence of T2C-0006

SEQ ID NO: 50: Amino acid sequence of a sense primer for heavy chain gene amplification

SEQ ID NO: 51: Nucleotide sequence of a first-run antisense primer for heavy chain gene amplification

SEQ ID NO: 52: Nucleotide sequence of second-run antisense primer for heavy chain gene amplification

SEQ ID NO: 53: Nucleotide sequence of a sense primer for light chain gene amplification

SEQ ID NO: 54: Nucleotide sequence of a first-run antisense primer for light chain gene amplification

SEQ ID NO: 55: Nucleotide sequence of a second-run antisense primer for light chain gene amplification

SEQ ID NO: 56: Nucleotide sequence of a sense primer for heavy chain sequencing

SEQ ID NO: 57: Nucleotide sequence of antisense primer 1 for light chain sequencing

SEQ ID NO: 58: Nucleotide sequence of antisense primer 2 for light chain sequencing

SEQ ID NO: 59: ORF nucleotide sequence encoding C3E-7078

SEQ ID NO: 60: Amino acid sequence of C3E-7078

SEQ ID NO: 61: ORF nucleotide sequence encoding C3E-7079

SEQ ID NO: 62: Amino acid sequence of C3E-7079

SEQ ID NO: 63: ORF nucleotide sequence encoding C3E-7085

SEQ ID NO: 64: Amino acid sequence of C3E-7085

SEQ ID NO: 65: ORF nucleotide sequence encoding C3E-7086

SEQ ID NO: 66: Amino acid sequence of C3E-7086

SEQ ID NO: 67: ORF nucleotide sequence encoding C3E-7087

SEQ ID NO: 68: Amino acid sequence of C3E-7087

SEQ ID NO: 69: ORF nucleotide sequence encoding C3E-7088

SEQ ID NO: 70: Amino acid sequence of C3E-7088

SEQ ID NO: 71: ORF nucleotide sequence encoding C3E-7089

SEQ ID NO: 72: Amino acid sequence of C3E-7089

SEQ ID NO: 73: ORF nucleotide sequence encoding C3E-7090

SEQ ID NO: 74: Amino acid sequence of C3E-7090

SEQ ID NO: 75: ORF nucleotide sequence encoding C3E-7091

SEQ ID NO: 76: Amino acid sequence of C3E-7091

SEQ ID NO: 77: ORF nucleotide sequence encoding C3E-7092

SEQ ID NO: 78: Amino acid sequence of C3E-7092

SEQ ID NO: 79: ORF nucleotide sequence encoding C3E-7093

SEQ ID NO: 80: Amino acid sequence of C3E-7093

SEQ ID NO: 81: ORF nucleotide sequence encoding C3E-7094

SEQ ID NO: 82: Amino acid sequence of C3E-7094

SEQ ID NO: 83: ORF nucleotide sequence encoding C3E-7095

SEQ ID NO: 84: Amino acid sequence of C3E-7095

SEQ ID NO: 85: Nucleotide sequence of a sense primer for C3E-7078

SEQ ID NO: 86: Nucleotide sequence of an antisense primer for C3E-7078

SEQ ID NO: 87: Nucleotide sequence of a sense primer for C3E-7079

SEQ ID NO: 88: Nucleotide sequence of an antisense primer for C3E-7079

SEQ ID NO: 89: (AXC-0001 ORF): ORF nucleotide sequence encoding AXC-0001

SEQ ID NO: 90: (AXC-0001 AA): Amino acid sequence of AXC-0001

SEQ ID NO: 91: (AXC-0002 ORF): ORF nucleotide

sequence encoding AXC-0002

SEQ ID NO: 92: (AXC-0002 AA): Amino acid sequence of AXC-0002

SEQ ID NO: 93: (MGC-0001 ORF): ORF nucleotide sequence encoding MGC-0001

SEQ ID NO: 94: (MGC-0001 AA): Amino acid sequence of MGC-0001

SEQ ID NO: 95: (MGC-0002 ORF): ORF nucleotide sequence encoding MGC-0002

SEQ ID NO: 96: (MGC-0002 AA): Amino acid sequence of MGC-0002

SEQ ID NO: 97: (MAGEC1 peptide): Amino acid sequence of MAGEC1 peptide

SEQ ID NO: 98: (CDRH2 of variants): Amino acid sequence of CDRH2 of a CDR variant

SEQ ID NO: 99: (CDRL2 of variants): Amino acid sequence of CDRL2 of a CDR variant

SEQ ID NO: 100: (VH of C3E-7034 variants): Amino acid sequence of the heavy chain variable region of the CDR variant of C3E-7034

SEQ ID NO: 101: (VL of C3E-7034 variants): Amino acid sequence of the light chain variable region of the CDR variant of C3E-7034

SEQ ID NO: 102: (VL of C3E-7035 variants): Amino acid sequence of the light chain variable region of the CDR variant of C3E-7035

SEQ ID NO: 103: (VL of C3E-7036 variants): Amino acid sequence of the light chain variable region of the

CDR variant of C3E-7036