DESCRIPTION

TITLE OF THE INVENTION: ANTI-B7-H3 ANTIBODY

Technical Field

[0001]

The present invention relates to an antibody which binds to B7-H3 and is useful as a therapeutic and/or preventive agent for a tumor, and also relates to a method of treating and/or preventing a tumor using the antibody.

Background Art

[0002]

B7-H3 is a protein having a single-pass transmembrane structure (Non-patent document 1). The N-terminal extracellular domain of B7-H3 contains two variants. Variant 1 contains a V-like and a C-like Ig domain, respectively, at each of two sites, and Variant 2 contains a V-like and a C-like Ig domain, respectively, at one site. The C-terminal intracellular domain of B7-H3 contains 45 amino acids.

[0003]

As a receptor for B7-H3, TLT-2 having a single-pass transmembrane structure has been reported (Non-patent document 2). However, there is also a report insisting that TLT-2 is not a receptor for B7-H3 (Non-patent document 3).

According to the former report, the activation of CD8-positive T cells is enhanced when the receptor is bound to B7-H3.

[0004]

It has been clinically reported that B7-H3 is overexpressed in many cancer types, particularly in non-small-cell lung cancer, kidney cancer, urothelial carcinoma, colorectal cancer, prostate cancer, glioblastoma multiforme, ovarian cancer, and pancreatic cancer (Non-patent documents 4 to 11). Further, it has been reported that in prostate cancer, the intensity of expression of B7-H3 positively correlates with clinicopathological malignancy such as tumor volume, extraprostatic invasion, or Gleason score, and also correlates with cancer progression (Non-patent document 8). Similarly, in glioblastoma multiforme, the expression of B7-H3 negatively correlates with event-free survival (Non-patent document 9), and in pancreatic cancer, the expression of B7-H3 correlates with lymph node metastasis and pathological progression (Non-patent document 11). In ovarian cancer, the expression of B7-H3 correlates with lymph node metastasis and pathological progression.

[0005]

Further, it has been reported that by introducing siRNA against the B7-H3 gene into a B7-H3-positive cancer cell line, adhesiveness to fibronectin is reduced thus reducing cell migration and matrigel invasion (Non-patent document 12).

Further, it has been reported that in glioblastoma multiforme, the expression of B7-H3 allows escape from NK cell-mediated cell death (Non-patent document 13).

[0006]

On the other hand, B7-H3 has been reported to be expressed not only in cancer cells, but also in tumors or surrounding vessels (Non-patent documents 5 and 14). It has been reported that when B7-H3 is expressed in ovarian cancer blood vessels, the survival rate is decreased.

[0007]

B7 family molecules have been suggested to be related to the immune system. B7-H3 has been reported to be expressed in monocytes, dendritic cells, and activated T cells (Non-patent document 15). It has been reported that as cytotoxic T cells are activated, B7-H3 costimulates the proliferation of CD4-positive or CD8-positive T cells. However, there is also a report that B7-H3 does not play a costimulatory role (Non-patent document 1).

[0008]

B7-H3 molecules have been reported to be related to autoimmune diseases. It has been reported that in rheumatism and other autoimmune diseases, B7-H3 plays an important role in the interaction between fibroblast-like synoviocytes and activated T-cells (Non-patent document 16) and that B7-H3 functions as a costimulatory factor when cytokines are released

from activated macrophages and therefore is related to the occurrence of sepsis (Non-patent document 17). Further, it has been reported that by administering an anti-B7-H3 antibody to a mouse model of asthma during the induction phase, asthma is improved due to the suppression of Th2 cell-mediated cytokine production in regional lymph nodes through the administration of an anti-mouse B7-H3 antibody (Non-patent document 18).

[0009]

With respect to B7-H3, it has been reported that an antibody against mouse B7-H3 enhances intratumoral infiltrating CD8-positive T cells and suppresses tumor growth (Non-patent document 14). Further, there is a patent which discloses that an antibody which recognizes B7-H3 variant 1 exhibits an in vivo antitumor effect on adenocarcinoma (Patent document 1).

[0010]

In spite of these studies, an epitope for an anti-B7-H3 antibody which exhibits an in vivo antitumor effect has not been clarified so far, and there has been no report that a specific amino acid sequence of the extracellular domain of B7-H3 is useful as an epitope for a monoclonal antibody for treating cancer.

[0011]

Even if antibodies are specific for the same antigen,

the properties of the antibodies may vary due to differences in epitopes or sequences of the antibodies. Due to the difference in properties of the antibodies, when being clinically administrated to humans, the antibodies exhibit different reactions in terms of the effectiveness of the medicinal agent, the frequency of therapeutic response, the incidence of side effects or drug resistance, etc.

Also as regards antibodies against B7-H3, the creation of an antibody having unprecedented properties has been strongly demanded.

Related Art Documents

Patent Document

[0012]

Patent Document 1: WO 2008/066691

Non-patent Documents

[0013]

Non-patent Document 1: The Journal of Immunology, 2004, vol. 172, pp. 2352-2359

Non-patent Document 2: Proceedings of the National Academy of Sciences of the United States of America, 2008, vol. 105, pp. 10495-10500

Non-patent Document 3: European Journal of Immunology, 2009, vol. 39 pp. 1754-1764

Non-patent Document 4: Lung Cancer, 2009, vol. 66, pp. 245-249

Non-patent Document 5: Clinical Cancer Research, 2008, vol. 14, pp. 5150-5157

Non-patent Document 6: Clinical Cancer Research 2008, vol. 14, pp. 4800-4808

Non-patent Document 7: Cancer Immunology, Immunotherapy, 2010, vol. 59, pp. 1163-1171

Non-patent Document 8: Cancer Research, 2007, vol. 67, pp. 7893-7900

Non-patent Document 9: Histopathology, 2008, vol. 53, pp. 73-80

Non-patent Document 10: Modern Pathology, 2010, vol. 23, pp. 1104-1112

Non-patent Document 11: British Journal of Cancer, 2009, vol. 101, pp. 1709-1716

Non-patent Document 12: Current Cancer Drug Targets, 2008, vol. 8, pp. 404-413

Non-patent Document 13: Proceedings of the National Academy of Sciences of the United States of America, 2004, vol. 101, pp. 12640-12645

Non-patent Document 14: Modern Pathology, 2010, vol. 23, pp. 1104-1112

Non-patent Document 15: Nature Immunology, 2001, vol. 2, pp. 269-274

Non-patent Document 16: The Journal of Immunology, 2008, vol. 180, pp. 2989-2998

Non-patent Document 17: The Journal of Immunology, 2010, vol. 185, pp. 3677-3684

Non-patent Document 18: The Journal of Immunology, 2008, vol. 181, pp. 4062-4071

Summary of the Invention

Problems to be Solved by the Invention

[0014]

An object of the invention is to provide an antibody and a functional fragment of the antibody to be used in a pharmaceutical having a therapeutic effect on a tumor, a method of treating a tumor using the antibody or a functional fragment of the antibody, and the like.

Means for Solving the Problems

[0015]

The present inventors made intensive studies in order to achieve the above object, and as a result, they found an antibody which specifically binds to B7-H3 to exhibit an antitumor activity, and thus completed the invention. That is, the invention includes the following inventions.

(1) An antibody characterized by having the following properties of:

(a) specifically binding to B7-H3;

(b) having an antibody-dependent cell-mediated phagocytosis (ADCP) activity; and

(c) having an in vivo antitumor activity,

or a functional fragment of the antibody.

(2) The antibody or a functional fragment of the antibody according to the above (1), wherein B7-H3 is a molecule including an amino acid sequence represented by SEQ ID NO: 6 or 10.

(3) The antibody or a functional fragment of the antibody according to the above (1) or (2), which binds to IgC1 and/or IgC2 each of which is a domain of B7-H3.

(4) The antibody or a functional fragment of the antibody according to the above (3), wherein IgC1 is a domain including an amino acid sequence represented by amino acid numbers 140 to 244 in SEQ ID NO: 6, and IgC2 is a domain including an amino acid sequence represented by amino acid numbers 358 to 456 in SEQ ID NO: 6.

(5) The antibody or a functional fragment of the antibody according to any one of the above (1) to (4), which has a competitive inhibitory activity against M30 antibody for the binding to B7-H3.

[0016]

(6) The antibody or a functional fragment of the antibody according to any one of the above (1) to (5), which has an

antibody-dependent cellular cytotoxicity (ADCC) activity and/or a complement-dependent cytotoxicity (CDC) activity.

(7) The antibody or a functional fragment of the antibody according to any one of the above (1) to (6), wherein the tumor is cancer.

(8) The antibody or a functional fragment of the antibody according to the above (7), wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.

(9) The antibody or a functional fragment of the antibody according to any one of the above (1) to (8), which comprises CDRH1 consisting of an amino acid sequence represented by SEQ ID NO: 92, CDRH2 consisting of an amino acid sequence represented by SEQ ID NO: 93, and CDRH3 consisting of an amino acid sequence represented by SEQ ID NO: 94 as complementarity determining regions of the heavy chain and comprises CDRL1 consisting of an amino acid sequence represented by SEQ ID NO: 95, CDRL2 consisting of an amino acid sequence represented by SEQ ID NO: 96, and CDRL3 consisting of an amino acid sequence represented by SEQ ID NO: 97 as complementarity determining regions of the light chain.

(10) The antibody or a functional fragment of the antibody according to any one of the above (1) to (9), which comprises a heavy chain variable region consisting of an amino

acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 51 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 23 to 130 in SEQ ID NO: 53.

(11) The antibody or a functional fragment of the antibody according to any one of the above (1) to (10), wherein a constant region is a human-derived constant region.

[0017]

(12) The antibody or a functional fragment of the antibody according to the above (11), which comprises a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 63 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 59.

(13) The antibody or a functional fragment of the antibody according to any one of the above (1) to (12), which is humanized.

(14) The antibody or a functional fragment of the antibody according to the above (13), which comprises: a heavy chain variable region consisting of an amino acid sequence selected from the group consisting of (a) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85, (b) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 87, (c) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 89, (d) an amino acid sequence represented by amino acid numbers 20 to 141 in

SEQ ID NO: 91, (e) an amino acid sequence having a homology of at least 95% or more with any of the sequences (a) to (d), and (f) an amino acid sequence wherein one or several amino acids are deleted, substituted or added in any of the sequences (a) to (d); and a light chain variable region consisting of an amino acid sequence selected from the group consisting of (g) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71, (h) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73, (i) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75, (j) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77, (k) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 79, (l) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 81, (m) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 83, (n) an amino acid sequence having a homology of at least 95% or more with any of the sequences (g) to (m), and (o) an amino acid sequence wherein one or several amino acids are deleted, substituted or added in any of the sequences (g) to (m).

(15) The antibody or a functional fragment of the antibody according to the above (14), which comprises a heavy chain variable region and a light chain variable region selected from the group consisting of: a heavy chain variable region consisting of an amino acid sequence represented by

amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 79; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 81; a heavy chain variable region consisting

of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting ofan amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 83; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75; and a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77.

(16) The antibody or a functional fragment of the antibody according to the above (14) or (15), which comprises a heavy chain and a light chain selected from the group consisting of: a heavy chain consisting of an amino acid

sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 79; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 81; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 83;

a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75; and a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77.

(17) The antibody or a functional fragment of the antibody according to any one of the above (14) to (16), which comprises a heavy chain and a light chain selected from the group consisting of: a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by SEQ

ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 75; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 77; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 79; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 81; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 83; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 75; and a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 77.

(18) The functional fragment of the antibody according to any one of the above (1) to (17), wherein the functional

fragment is selected from the group consisting of Fab, F(ab)2, Fab' and Fv.

(19) A polynucleotide encoding the antibody or a functional fragment of the antibody according to any one of the above (1) to (18).

(20) The polynucleotide according to the above (19), which comprises a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 50 and a nucleotide sequence represented by nucleotide numbers 67 to 390 in SEQ ID NO: 52.

(21) The polynucleotide according to the above (19) or (20), which includes a nucleotide sequence represented by SEQ ID NO: 62 and a nucleotide sequence represented by SEQ ID NO: 58.

(22) The polynucleotide according to the above (19) or (20), which comprises: a nucleotide sequence selected from the group consisting of (a) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84, (b) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 86, (c) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 88, (d) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90, and (e) a nucleotide sequence comprising a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary to any of the nucleotide sequences (a)

to (d) under stringent conditions; and a nucleotide sequence selected from the group consisting of (f) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70, (g) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72, (h) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74, (i) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76, (j) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 78, (k) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 80, (l) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 82, and (m) a nucleotide sequence comprising a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary to any of the nucleotide sequences (f) to (l) under stringent conditions.

(23) The polynucleotide according to the above (22), which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ

ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 78; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 80; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 82; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74; and a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76.

(24) The polynucleotide according to the above (22) or

(23), which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 74; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 76; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 78; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 80; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 82; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ

ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 74; and a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 76.

(25) The polynucleotide according to any one of the above (22) to (24), which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 70; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 72; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 74; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 76; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 78; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 80; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 82; a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 70; a nucleotide sequence represented

by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 72; a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 74; and a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 76.

[0018]

(26) An expression vector including a polynucleotide according to any one of the above (19) to (25).

(27) A host cell, which is transformed with the expression vector according to the above (26).

(28) The host cell according to the above (27), wherein the host cell is a eukaryotic cell.

(29) A method of producing an antibody or a functional fragment of the antibody, characterized by including a step of culturing the host cell according to the above (27) or (28) and a step of collecting a desired antibody or a functional fragment of the antibody from a cultured product obtained in the culturing step.

(30) An antibody or a functional fragment of the antibody, characterized by being obtained by the production method according to the above (29).

(31) The functional fragment of the antibody according to the above (30), wherein the functional fragment is selected from the group consisting of Fab, F(ab)2, Fab' and Fv.

(32) The antibody or a functional fragment of the

antibody according to any one of the above (1) to (18), (30), and (31), wherein the modification of a glycan is regulated to enhance an antibody-dependent cellular cytotoxic activity.

(33) A pharmaceutical composition characterized by including at least one of the antibodies or functional fragments of the antibodies according to the above (1) to (18), and (30) to (32).

[0019]

(34) The pharmaceutical composition according to the above (33), which is for treating a tumor.

(35) A pharmaceutical composition for treating a tumor characterized by including at least one of the antibodies or functional fragments of the antibodies according to the above (1) to (18), and (30) to (32) and at least one therapeutic agent for cancer.

[0020]

(36) The pharmaceutical composition according to the above (34) or (35), wherein the tumor is cancer.

(37) The pharmaceutical composition according to the above (36), wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.

(38) A method of treating a tumor, characterized by administering at least one of the antibodies or functional

fragments of the antibodies according to the above (1) to (18), and (30) to (32) to an individual.

(39) A method of treating a tumor, characterized by administering at least one of the antibodies or functional fragments of the antibodies according to the above (1) to (18), and (30) to (32) and at least one therapeutic agent for cancer simultaneously, separately, or sequentially to an individual.

[0021]

(40) The treatment method according to the above (38) or (39), wherein the tumor is cancer.

(41) The treatment method according to the above (40), wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.

Advantage of the Invention

[0022]

According to the invention, a therapeutic agent or the like for cancer comprising an antibody which binds to B7-H3 and has an antitumor activity against cancer cells can be obtained.

Brief Description of the Drawings

[0023]

[Fig. 1] Fig. 1 is a view showing the presence or absence of ADCP activity of an anti-B7-H3 antibody against NCI-H322 cells. The error bars in the drawing represent standard errors (n=3).

[Fig. 2] Fig. 2 is a view showing the presence or absence of ADCP activity of a commercially available anti-B7-H3 antibody against NCI-H322 cells.

[Fig. 3] Fig. 3 is a view showing the presence or absence of ADCC activity of M30 antibody against empty vector-transfected 293 cells and B7-H3-expressing 293 cells. The error bars in the drawing represent standard errors (n=3). In the drawing, the “mock” denotes the ADCC activity of M30 against empty vector-transfected 293 cells, and the “B7H3” denotes the ADCC activity of M30 against B7-H3-expressing 293 cells.

[Fig. 4] Fig. 4 is a view showing the presence or absence of CDC activity of an anti-B7-H3 antibody against NCI-H322 cells. The error bars in the drawing represent standard errors (n=3).

[Fig. 5-1] Fig. 5-1 is a view showing the reactivity of M30 antibody against a B7-H3 deficient mutant (B7-H3 IgV1). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 5-2] Fig. 5-2 is a view showing the reactivity of

M30 antibody against a B7-H3 deficient mutant (B7-H3 IgC1). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 5-3] Fig. 5-3 is a view showing the reactivity of M30 antibody against a B7-H3 deficient mutant (B7-H3 IgV2). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 5-4] Fig. 5-4 is a view showing the reactivity of M30 antibody against a B7-H3 deficient mutant (B7-H3 IgC2). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 5-5] Fig. 5-5 is a view showing the reactivity of M30 antibody against a B7-H3 deficient mutant (B7-H3 IgC1-V2-C2). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 5-6] Fig. 5-6 is a view showing the reactivity of M30 antibody against a B7-H3 deficient mutant (B7-H3 IgV2-C2). The dotted line indicates the binding property of a control antibody, and the solid line indicates the binding property of an M30 antibody.

[Fig. 6] Fig. 6 is a view showing the antitumor activities

of an anti-B7-H3 antibodies against mice implanted with NCI-H322 cells. The error bars in the drawing represent standard errors (n=10).

[Fig. 7] Fig. 7 is a view showing the antitumor activity of M30 antibody when macrophages were depleted in vivo. The error bars in the drawing represent standard errors (n=8). Further, the "mm^3" denotes "mm^3".

[Fig. 8] Fig. 8 is a view showing the ADCP activities of M30 antibody and cM30 antibody against NCI-H322 cells. The error bars in the drawing represent standard errors (n=4).

[Fig. 9] Fig. 9 is a view showing the antitumor activities of M30 antibody and cM30 antibody against mice implanted with MDA-MB-231 cells. The error bars in the drawing represent standard errors (n=9).

[Fig. 10-1] Fig. 10-1 is a view showing the competitive inhibitory activities of cM30 antibody and M30-H1-L4 antibody against M30 for the binding to an extracellular domain polypeptide antigen of a B7-H3 variant 1 antigen. The error bars in the drawing represent standard errors (n=3).

[Fig. 10-2] Fig. 10-2 is a view showing the competitive inhibitory activities of cM30 antibody and M30-H1-L4 antibody against M30 for the binding to an extracellular domain polypeptide antigen of a B7-H3 variant 2 antigen. The error bars in the drawing represent standard errors (n=3).

[Fig. 11] Fig. 11 is a view showing the ADCP activities

of M30 antibody, cM30 antibody, and M30-H1-L4 antibody against NCI-H322 cells. The error bars in the drawing represent standard errors (n=4).

[Fig. 12] Fig. 12 is a view showing the ADCC activities of cM30 antibody and M30-H1-L4 antibody against NCI-H322 cells. The error bars in the drawing represent standard errors (n=3).

[Fig. 13-1] Fig. 13-1 shows a nucleotide sequence of B7-H3 variant 1 (SEQ ID NO: 5).

[Fig. 13-2] Fig. 13-2 shows an amino acid sequence of the B7-H3 variant 1 (SEQ ID NO: 6).

[Fig. 14-1] Fig. 14-1 shows a nucleotide sequence of B7-H3 variant 2 (SEQ ID NO: 9).

[Fig. 14-2] Fig. 14-2 shows an amino acid sequence of the B7-H3 variant 2 (SEQ ID NO: 10).

[Fig. 15-1] Fig. 15-1 shows a nucleotide sequence of B7-H3 IgV1 (SEQ ID NO: 20).

[Fig. 15-2] Fig. 15-2 shows an amino acid sequence of the B7-H3 IgV1 (SEQ ID NO: 21).

[Fig. 16-1] Fig. 16-1 shows a nucleotide sequence of B7-H3 IgC1 (SEQ ID NO: 22).

[Fig. 16-2] Fig. 16-2 shows an amino acid sequence of the B7-H3 IgC1 (SEQ ID NO: 23).

[Fig. 17-1] Fig. 17-1 shows a nucleotide sequence of B7-H3 IgV2 (SEQ ID NO: 24).

[Fig. 17-2] Fig. 17-2 shows an amino acid sequence of

the B7-H3 IgV2 (SEQ ID NO: 25).

[Fig. 18-1] Fig. 18-1 shows a nucleotide sequence of B7-H3 IgC2 (SEQ ID NO: 26).

[Fig. 18-2] Fig. 18-2 shows an amino acid sequence of the B7-H3 IgC2 (SEQ ID NO: 27).

[Fig. 19-1] Fig. 19-1 shows a nucleotide sequence of B7-H3 IgC1-V2-C2 (SEQ ID NO: 28).

[Fig. 19-2] Fig. 19-2 shows an amino acid sequence of the B7-H3 IgC1-V2-C2 (SEQ ID NO: 29).

[Fig. 20-1] Fig. 20-1 shows a nucleotide sequence of B7-H3 IgV2-C2 (SEQ ID NO: 30).

[Fig. 20-2] Fig. 20-2 shows an amino acid sequence of B7-H3 IgV2-C2 (SEQ ID NO: 31).

[Fig. 21-1] Fig. 21-1 shows a nucleotide sequence of an M30 antibody heavy chain (SEQ ID NO: 50).

[Fig. 21-2] Fig. 21-2 shows an amino acid sequence of the M30 antibody heavy chain (SEQ ID NO: 51).

[Fig. 22-1] Fig. 22-1 shows a nucleotide sequence of an M30 antibody light chain (SEQ ID NO: 52).

[Fig. 22-2] Fig. 22-2 shows an amino acid sequence of the M30 antibody light chain (SEQ ID NO: 53).

[Fig. 23] Fig. 23 shows a nucleotide sequence of a human κ chain secretory signal, a human κ chain constant region, and a human poly-A additional signal (SEQ ID NO: 56).

[Fig. 24] Fig. 24 shows a nucleotide sequence of a signal

sequence and a constant region of human IgG1 (SEQ ID 57).

[Fig. 25-1] Fig. 25-1 shows a nucleotide sequence of an M30 antibody chimera-type light chain (SEQ ID NO: 58).

[Fig. 25-2] Fig. 25-2 shows an amino acid sequence of the M30 antibody chimera-type light chain (SEQ ID NO: 59).

[Fig. 26-1] Fig. 26-1 shows a nucleotide sequence of an M30 antibody chimera-type heavy chain (SEQ ID NO: 62).

[Fig. 26-2] Fig. 26-2 shows an amino acid sequence of the M30 antibody chimera-type heavy chain (SEQ ID NO: 63).

[Fig. 27-1] Fig. 27-1 shows a nucleotide sequence of an M30-L1-type light chain (SEQ ID NO: 70).

[Fig. 27-2] Fig. 27-2 shows an amino acid sequence of the M30-L1-type light chain (SEQ ID NO: 71).

[Fig. 28-1] Fig. 28-1 shows a nucleotide sequence of an M30-L2-type light chain (SEQ ID NO: 72).

[Fig. 28-2] Fig. 28-2 shows an amino acid sequence of the M30-L2-type light chain (SEQ ID NO: 73).

[Fig. 29-1] Fig. 29-1 shows a nucleotide sequence of an M30-L3-type light chain (SEQ ID NO: 74).

[Fig. 29-2] Fig. 29-2 shows an amino acid sequence of the M30-L3-type light chain (SEQ ID NO: 75).

[Fig. 30-1] Fig. 30-1 shows a nucleotide sequence of an M30-L4-type light chain (SEQ ID NO: 76).

[Fig. 30-2] Fig. 30-2 shows an amino acid sequence of the M30-L4-type light chain (SEQ ID NO: 77).

[Fig. 31-1] Fig. 31-1 shows a nucleotide sequence of an M30-L5-type light chain (SEQ ID NO: 78).

[Fig. 31-2] Fig. 31-2 shows an amino acid sequence of the M30-L5-type light chain (SEQ ID NO: 79).

[Fig. 32-1] Fig. 32-1 shows a nucleotide sequence of an M30-L6-type light chain (SEQ ID NO: 80).

[Fig. 32-2] Fig. 32-2 shows an amino acid sequence of the M30-L6-type light chain (SEQ ID NO: 81).

[Fig. 33-1] Fig. 33-1 shows a nucleotide sequence of an M30-L7-type light chain (SEQ ID NO: 82).

[Fig. 33-2] Fig. 33-2 shows an amino acid sequence of the M30-L7-type light chain (SEQ ID NO: 83).

[Fig. 34-1] Fig. 34-1 shows a nucleotide sequence of an M30-H1-type heavy chain (SEQ ID NO: 84).

[Fig. 34-2] Fig. 34-2 shows an amino acid sequence of the M30-H1-type heavy chain (SEQ ID NO: 85).

[Fig. 35-1] Fig. 35-1 shows a nucleotide sequence of an M30-H2-type heavy chain (SEQ ID NO: 86).

[Fig. 35-2] Fig. 35-2 shows an amino acid sequence of the M30-H2-type heavy chain (SEQ ID NO: 87).

[Fig. 36-1] Fig. 36-1 shows a nucleotide sequence of an M30-H3-type heavy chain (SEQ ID NO: 88).

[Fig. 36-2] Fig. 36-2 shows an amino acid sequence of the M30-H3-type heavy chain (SEQ ID NO: 89).

[Fig. 37-1] Fig. 37-1 shows a nucleotide sequence of an

M30-H4-type heavy chain (SEQ ID NO: 90).

[Fig. 37-2] Fig. 37-2 shows an amino acid sequence of the M30-H4-type heavy chain (SEQ ID NO: 91).

[Fig. 38] Fig. 38 is a view showing the antitumor activity of a humanized M30 (M30-H1-L4) antibody against mice implanted with MDA-MB-231 cells. The error bars in the drawing represent standard errors (n=6).

Mode for Carrying Out the Invention

[0024]

The terms “cancer” and “tumor” as used herein are used with the same meaning.

[0025]

The term “gene” as used herein includes not only DNA, but also mRNA thereof, cDNA thereof and cRNA thereof.

[0026]

The term “polynucleotide” as used herein is used with the same meaning as a nucleic acid and also includes DNA, RNA, probes, oligonucleotides, and primers.

[0027]

The terms “polypeptide” and “protein” as used herein are used without distinction.

[0028]

The term “cell” as used herein also includes cells in an animal individual and cultured cells.

The term “B7-H3” as used herein is used in the same meaning as B7-H3 protein, and also refers to B7-H3 variant 1 and/or B7-H3 variant 2.

[0029]

The term “cell injury” as used herein refers to a state in which a pathological change is caused to cells in some form, and the cell injury is not limited to direct injury and includes all sorts of damage to the structure and function of cells such as DNA cleavage, base-dimer formation, chromosomal cleavage, damage to cell division machinery, and a decrease in various enzymatic activities.

[0030]

The term “cytotoxic activity” as used herein refers to the activity of causing the above-described cell injury.

The term “antibody-dependent cell-mediated phagocytosis activity” as used herein refers to “antibody-dependent cell phagocytosis (ADCP) activity” and means the activity of phagocytosing target cells such as tumor cells by monocytes or macrophages mediated by an antibody. The term is also called “antibody-dependent phagocytosis activity”.

The term “antibody-dependent cellular cytotoxicity activity” as used herein refers to “antibody-dependent cellular cytotoxicity (ADCC) activity” and means the activity of damaging target cells such as tumor cells by NK cells

mediated by an antibody.

The term "complement-dependent cytotoxicity activity" as used herein refers to "complement-dependent cytotoxicity (CDC) activity" and means the activity of damaging target cells such as tumor cells by complement mediated by an antibody.

[0031]

The term "functional fragment of an antibody" as used herein refers to a partial fragment of an antibody having an antigen-binding activity, wherein the fragment has a full or partial function of the antibody, including Fab, F(ab')2, scFv, and the like. The term also includes Fab' which is a monovalent fragment in a variable region of an antibody obtained by treating F(ab')2 under reducing conditions. However, the term is not limited to these molecules as long as the fragment has a binding affinity for an antigen. Further, these functional fragments include not only a fragment obtained by treating a full-length molecule of an antibody protein with an appropriate enzyme, but also a protein produced in an appropriate host cell using a genetically modified antibody gene.

[0032]

The term "Fab'" as used herein refers to a monovalent fragment in a variable region of an antibody obtained by treating F(ab')2 under reducing conditions as described above. However, Fab' produced using a genetically modified antibody gene is also included in the Fab' of the invention.

[0033]

The term “epitope” as used herein refers to a partial peptide or a partial tertiary structure of B7-H3 to which a specific anti-B7-H3 antibody binds. The epitope which is a partial peptide of the above-described B7-H3 can be determined by a method well known to those skilled in the art such as an immunoassay, and for example, the following method can be employed. First, various partial structures of an antigen are produced. In the production of the partial structures, a known oligopeptide synthesis technique can be used. For example, a series of polypeptides having appropriately reduced lengths obtained by sequentially shortening B7-H3 from the C terminus or N terminus are produced using a genetic recombination technique known to those skilled in the art. Thereafter, the reactivity of an antibody against these polypeptides is examined and a recognition site is roughly determined. Then, peptides having shorter lengths are synthesized and the reactivity of the antibody with these peptides is examined, whereby the epitope can be determined. Further, the epitope which is a partial tertiary structure of an antigen to which a specific antibody binds can be determined by specifying the amino acid residues of the antigen which lie adjacent to the antibody by X-ray structural analysis.

The phrase “antibodies which bind to the same epitope” as used herein refers to different antibodies which bind to

a common epitope. If a second antibody binds to a partial peptide or a partial tertiary structure to which a first antibody binds, it can be determined that the first antibody and the second antibody bind to the same epitope. Further, by confirming that a second antibody competes with a first antibody for the binding to an antigen (that is, the second antibody inhibits the binding between the first antibody and the antigen), it can be determined that the first antibody and the second antibody bind to the same epitope even if the specific epitope sequence or structure has not been determined. Further, when the first antibody and the second antibody bind to the same epitope and also the first antibody has a special activity such as an antitumor activity, it can be expected that the second antibody also has the same activity. Accordingly, when a second anti-B7-H3 antibody binds to a partial peptide to which a first anti-B7-H3 antibody binds, it can be determined that the first antibody and the second antibody bind to the same epitope of B7-H3. Further, by confirming that a second anti-B7-H3 antibody competes with a first anti-B7-H3 antibody for the binding to B7-H3, it can be determined that the first antibody and the second antibody are antibodies which bind to the same epitope of B7-H3.

[0034]

The term "CDR" as used herein refers to a complementarity determining region (CDR), and it is known that each heavy and

light chain of an antibody molecule has three complementarity determining regions (CDRs). The CDR is also called the hypervariable region, and is present in a variable region of each heavy and light chain of an antibody. It is a site which has unusually high variability in its primary structure, and there are three separate CDRs in the primary structure of each heavy and light polypeptide chain. In this specification, with regard to the CDRs of an antibody, the CDRs of the heavy chain are represented by CDRH1, CDRH2, and CDRH3 from the amino-terminal side of the amino acid sequence of the heavy chain, and the CDRs of the light chain are represented by CDRL1, CDRL2, and CDRL3 from the amino-terminal side of the amino acid sequence of the light chain. These sites are proximate to one another in the tertiary structure and determine the specificity for an antigen to which the antibody binds.

[0035]

The phrase "hybridization is performed under stringent conditions" as used herein refers to a process in which hybridization is performed under conditions under which identification can be achieved by performing hybridization at 68°C in a commercially available hybridization solution ExpressHyb Hybridization Solution (manufactured by Clontech, Inc.) or by performing hybridization at 68°C in the presence of 0.7 to 1.0 M NaCl using a filter having DNA immobilized thereon, followed by performing washing at 68°C using 0.1 to

2 x SSC solution (1 x SSC solution is composed of 150 mM NaCl and 15 mM sodium citrate) or under conditions equivalent thereto.

1. B7-H3

B7-H3 is a member of the B7 family expressed on antigen-presenting cells as a costimulatory molecule, and is considered to act on a receptor on T cells to enhance or suppress immune activity.

B7-H3 is a protein having a single-pass transmembrane structure, and the N-terminal extracellular domain of B7-H3 contains two variants. The B7-H3 variant 1 (4Ig-B7-H3) contains a V-like or C-like Ig domain at two sites, respectively, and the B7-H3 variant 2 (2Ig-B7-H3) contains a V-like or C-like Ig domain at one site, respectively.

As for B7-H3 to be used in the invention, B7-H3 can be directly purified from B7-H3-expressing cells of a human or a non-human mammal (such as a rat or a mouse) and used, or a cell membrane fraction of the above-described cells can be prepared and used. Further, B7-H3 can be obtained by in vitro synthesis thereof or production thereof in a host cell through genetic engineering. In such genetic engineering, specifically, after B7-H3 cDNA is integrated into a vector capable of expressing B7-H3 cDNA, B7-H3 can be obtained by synthesizing it in a solution containing enzymes, substrates

and energy substances required for transcription and translation, or by expressing B7-H3 in another prokaryotic or eucaryotic transformed host cell .

The nucleotide sequence of an open reading frame (ORF) of a human B7-H3 variant 1 gene is represented by SEQ ID NO: 5 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 6 in the Sequence Listing. Further, the sequences of SEQ ID NOS: 5 and 6 are shown in Fig. 13.

The nucleotide sequence of an ORF of a human B7-H3 variant 2 gene is represented by SEQ ID NO: 9 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 10 in the Sequence Listing. Further, the sequences of SEQ ID NOS: 9 and 10 are shown in Fig. 14.

Further, a protein which consists of an amino acid sequence wherein one or several amino acids are substituted, deleted and/or added in any of the above-described amino acid sequences of B7-H3 and also has a biological activity equivalent to that of the protein is also included in B7-H3.

[0036]

Mature human B7-H3 variant 1 from which the signal sequence has been removed corresponds to an amino acid sequence consisting of amino acid residues 27 to 534 of the amino acid sequence represented by SEQ ID NO: 6. Further, mature human B7-H3 variant 2 from which the signal sequence has been removed corresponds to an amino acid sequence consisting of amino acid

residues 27 to 316 of the amino acid sequence represented by SEQ ID NO: 10.

In the B7-H3 variant 1, the respective domains are present in the order of IgV1, IgC1, IgV2, and IgC2 from the N terminus, and in SEQ ID NO: 6 in the Sequence Listing, IgV1 corresponds to amino acid numbers 27 to 139, IgC1 corresponds to amino acid numbers 140 to 244, IgV2 corresponds to amino acid numbers 245 to 357, and IgC2 corresponds to amino acid numbers 358 to 456. Further, in the B7-H3 variant 2, the respective domains are present in the order of IgV1 and IgC2 from the N terminus, and in SEQ ID NO: 10 in the Sequence Listing, IgV1 corresponds to amino acid numbers 27 to 140 and IgC2 corresponds to amino acid numbers 141 to 243.

[0037]

B7-H3 cDNA can be obtained by, for example, a so-called PCR method in which a polymerase chain reaction (hereinafter referred to as "PCR") is performed using a cDNA library expressing B7-H3 cDNA as a template and primers which specifically amplify B7-H3 cDNA (Saiki, R. K., et al., Science, (1988) 239, 487-49). Incidentally, a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary to the nucleotide sequence represented by SEQ ID NO: 5 or 9 in the Sequence Listing under stringent conditions and encodes a protein having a biological activity equivalent to that of B7-H3 is also included in B7-H3 cDNA.

Further, a polynucleotide which is a splicing variant transcribed from the human or mouse B7-H3 locus or a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary thereto under stringent conditions and encodes a protein having a biological activity equivalent to that of B7-H3 is also included in B7-H3 cDNA.

[0038]

Further, a protein which consists of an amino acid sequence wherein one or several amino acids are substituted, deleted or added in the amino acid sequence represented by SEQ ID NO: 6 or 10 in the Sequence Listing or an amino acid sequence obtained by removing the signal sequence from either of these sequences and has a biological activity equivalent to that of B7-H3 is also included in B7-H3. Further, a protein which consists of an amino acid sequence encoded by a splicing variant transcribed from the human or mouse B7-H3 locus or an amino acid sequence wherein one or several amino acids are substituted, deleted or added in the above amino acid sequence and has a biological activity equivalent to that of B7-H3 is also included in B7-H3.

2. Production of anti-B7-H3 antibody

The antibody against B7-H3 of the invention can be obtained by immunizing an animal with B7-H3 or an arbitrary polypeptide selected from the amino acid sequence of B7-H3, and collecting and purifying the antibody produced in vivo

according to common procedures. The biological species of B7-H3 to be used as an antigen is not limited to being human, and an animal can be immunized with B7-H3 derived from an animal other than humans such as a mouse or a rat. In this case, by examining the cross-reactivity between an antibody binding to the obtained heterologous B7-H3 and human B7-H3, an antibody applicable to a human disease can be selected.

[0039]

Further, a monoclonal antibody can be obtained from a hybridoma established by fusing antibody-producing cells which produce an antibody against B7-H3 with myeloma cells according to known methods (for example, Kohler and Milstein, Nature, (1975) 256, pp. 495-497; Kennet, R. ed., Monoclonal Antibodies, pp. 365-367, Plenum Press, N.Y. (1980)).

[0040]

Incidentally, B7-H3 to be used as an antigen can be obtained by expressing the B7-H3 gene in a host cell using genetic enginering.

[0041]

Specifically, a vector capable of expressing the B7-H3 gene is produced, and the resulting vector is transfected into a host cell to express the gene, and then, the expressed B7-H3 is purified. Hereinafter, a method of obtaining an antibody against B7-H3 will be specifically described.

(1) Preparation of antigen

Examples of the antigen to be used for producing the anti-B7-H3 antibody include B7-H3, a polypeptide consisting of a partial amino acid sequence comprising at least 6 consecutive amino acids of B7-H3, and a derivative obtained by adding a given amino acid sequence or carrier thereto.

[0042]

B7-H3 can be purified directly from human tumor tissues or tumor cells and used. Further, B7-H3 can be obtained by synthesizing it in vitro or by producing it in a host cell by genetic engineering.

[0043]

With respect to such genetic engineering, specifically, after B7-H3 cDNA is integrated into a vector capable of expressing B7-H3 cDNA, B7-H3 can be obtained by synthesizing it in a solution containing enzymes, substrates and energy substances required for transcription and translation, or by expressing B7-H3 in another prokaryotic or eucaryotic transformed host cell.

[0044]

Further, the antigen can also be obtained as a secretory protein by expressing a fusion protein obtained by ligating the extracellular domain of B7-H3, which is a membrane protein, to the constant region of an antibody in an appropriate host-vector system.

[0045]

B7-H3 cDNA can be obtained by, for example, a so-called PCR method in which a polymerase chain reaction (hereinafter referred to as "PCR") is performed using a cDNA library expressing B7-H3 cDNA as a template and primers which specifically amplify B7-H3 cDNA (see Saiki, R. K., et al., Science, (1988) 239, pp. 487-489).

[0046]

As the system for in vitro synthesis of the polypeptide, for example, Rapid Translation System (RTS) manufactured by Roche Diagnostics, Inc. can be exemplified, but it is not limited thereto.

[0047]

Examples of prokaryotic host cells include Escherichia coli and Bacillus subtilis. In order to transform the host cells with a target gene, the host cells are transformed by a plasmid vector comprising a replicon, i.e., a replication origin derived from a species compatible with the host, and a regulatory sequence. Further, the vector preferably has a sequence capable of imposing phenotypic selectivity on the transformed cell.

[0048]

Examples of eucaryotic host cells include vertebrate cells, insect cells, and yeast cells. As the vertebrate cells, for example, simian COS cells (Gluzman, Y., Cell, (1981) 23,

pp. 175-182, ATCC CRL-1650), murine fibroblasts NIH3T3 (ATCC No. CRL-1658), and dihydrofolate reductase-deficient strains (Urlaub, G. and Chasin, L. A., Proc. Natl. Acad. Sci. USA (1980) 77, pp. 4126-4220) of Chinese hamster ovarian cells (CHO cells; ATCC: CCL-61); and the like are often used, however, the cells are not limited thereto.

[0049]

The thus obtained transformant can be cultured according to common procedures, and by culturing the transformant, a target polypeptide is produced intracellularly or extracellularly.

[0050]

A suitable medium to be used for culturing can be selected from various commonly used culture media depending on the employed host cells. If Escherichia coli is employed, for example, an LB medium supplemented with an antibiotic such as ampicillin or IPMG as needed can be used.

[0051]

A recombinant protein produced intracellularly or extracellularly by the transformant through such culturing can be separated and purified by any of various known separation methods utilizing the physical or chemical properties of the protein.

[0052]

Specific examples of the methods include treatment with

a common protein precipitant, ultrafiltration, various types of liquid chromatography such as molecular sieve chromatography (gel filtration), adsorption chromatography, ion exchange chromatography, and affinity chromatography, dialysis, and a combination thereof.

[0053]

Further, by attaching a tag of six histidine residues to a recombinant protein to be expressed, the protein can be efficiently purified with a nickel affinity column. Alternatively, by attaching the IgG Fc region to a recombinant protein to be expressed, the protein can be efficiently purified with a protein A column.

[0054]

By combining the above-described methods, a large amount of a target polypeptide can be easily produced in high yield and high purity.

(2) Production of anti-B7-H3 monoclonal antibody

Examples of the antibody specifically binding to B7-H3 include a monoclonal antibody specifically binding to B7-H3, and a method of obtaining such an antibody is described below.

[0055]

The production of a monoclonal antibody generally requires the following operational steps of:

(a) purifying a biopolymer to be used as an antigen;

(b) preparing antibody-producing cells by immunizing an animal by injection of the antigen, collecting the blood, assaying its antibody titer to determine when the spleen is excised;

(c) preparing myeloma cells (hereinafter referred to as "myeloma");

(d) fusing the antibody-producing cells with the myeloma;

(e) screening a group of hybridomas producing a desired antibody;

(f) dividing the hybridomas into single cell clones (cloning);

(g) optionally, culturing the hybridoma or rearing an animal implanted with the hybridoma for producing a large amount of a monoclonal antibody;

(h) examining the thus produced monoclonal antibody for biological activity and binding specificity, or examining the properties of the antibody as a labeled antibody reagent; and the like.

[0056]

Hereinafter, the method of producing a monoclonal antibody will be described in detail following the above steps, however, the method is not limited thereto, and, for example, antibody-producing cells other than spleen cells and myeloma can be used.

[0057]

(a) Purification of antigen

As the antigen, B7-H3 prepared by the method as described above or a partial peptide thereof can be used.

[0058]

Further, a membrane fraction prepared from recombinant cells expressing B7-H3 or the recombinant cells expressing B7-H3 themselves, and also a partial peptide of the protein of the invention chemically synthesized by a method known to those skilled in the art can also be used as the antigen.

[0059]

(b) Preparation of antibody-producing cells

The antigen obtained in step (a) is mixed with an adjuvant such as Freund's complete or incomplete adjuvant or aluminum potassium sulfate and the resulting mixture is used as an immunogen to immunize an experimental animal. As the experimental animal, any animal used in a known hybridoma production method can be used without any trouble. Specifically, for example, a mouse, a rat, a goat, sheep, cattle, a horse, or the like can be used. However, from the viewpoint of ease of availability of myeloma cells to be fused with the extracted antibody-producing cells, a mouse or a rat is preferably used as the animal to be immunized.

[0060]

Further, the strain of mouse or rat to be used is not

particularly limited, and in the case of a mouse, for example, various strains such as A, AKR, BALB/c, BDP, BA, CE, C3H, 57BL, C57BL, C57L, DBA, FL, HTH, HT1, LP, NZB, NZW, RF, R III, SJL, SWR, WB, and 129 and the like can be used, and in the case of a rat, for example, Wistar, Low, Lewis, Sprague Dawley, ACI, BN, Fischer and the like can be used.

These mice and rats are commercially available from breeders/distributors of experimental animals, for example, CLEA Japan, Inc. and Charles River Laboratories Japan, Inc.

[0061]

Among these, in consideration of compatibility of fusing with myeloma cells described below, in the case of a mouse, BALB/c strain, and in the case of a rat, Wistar and Low strains are particularly preferred as the animal to be immunized.

[0062]

Further, in consideration of antigenic homology between humans and mice, it is also preferred to use a mouse having decreased biological function to remove autoantibodies, that is, a mouse with an autoimmune disease.

[0063]

The age of such mouse or rat at the time of immunization is preferably 5 to 12 weeks of age, more preferably 6 to 8 weeks of age.

[0064]

In order to immunize an animal with B7-H3 or a recombinant

thereof, for example, a known method described in detail in, for example, 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 Springfield, Illinois (1964) or the like can be used.

Among these immunization methods, a preferred specific method of the invention is, for example, as follows.

[0065]

That is, first, a membrane protein fraction serving as the antigen or cells caused to express the antigen is/are intradermally or intraperitoneally administered to an animal.

[0066]

However, the combination of both routes of administration is preferred for increasing the immunization efficiency, and when intradermal administration is performed in the first half and intraperitoneal administration is performed in the latter half or only at the last dosing, the immunization efficiency can be particularly increased.

[0067]

The administration schedule of the antigen varies depending on the type of animal to be immunized, individual differences or the like. However, in general, an administration schedule in which the number of times antigen is administered is 3 to 6 times and the dosing interval is 2

to 6 weeks is preferred, and an administration schedule in which the number of times antigen is administered is 3 to 4 times and the dosing interval is 2 to 4 weeks is more preferred.

[0068]

Further, the dose of the antigen varies depending on the type of animal, individual differences or the like, however, the dose is generally set to 0.05 to 5 mg, preferably about 0.1 to 0.5 mg.

[0069]

A booster immunization is performed 1 to 6 weeks, preferably 2 to 4 weeks, more preferably 2 to 3 weeks after the administration of the antigen as described above.

[0070]

The dose of the antigen at the time of performing the booster immunization varies depending on the type or size of animal or the like, however, in the case of, for example, a mouse, the dose is generally set to 0.05 to 5 mg, preferably 0.1 to 0.5 mg, more preferably about 0.1 to 0.2 mg.

[0071]

Spleen cells or lymphocytes including antibody-producing cells are aseptically removed from the immunized animal 1 to 10 days, preferably 2 to 5 days, more preferably 2 to 3 days after the booster immunization. At this time, the antibody titer is measured, and if an animal having a sufficiently increased antibody titer is used as a supply

source of the antibody-producing cells, the subsequent procedure can be carried out more efficiently.

[0072]

Examples of the method of measuring the antibody titer to be used here include an RIA method and an ELISA method, but the method is not limited thereto.

[0073]

For example, if an ELISA method is employed, the measurement of the antibody titer in the invention can be carried out according to the procedures as described below.

[0074]

First, a purified or partially purified antigen is adsorbed to the surface of a solid phase such as a 96-well plate for ELISA, and the surface of the solid phase having no antigen adsorbed thereto is covered with a protein unrelated to the antigen such as bovine serum albumin (hereinafter referred to as "BSA"). After washing the surface, the surface is brought into contact with a serially-diluted sample (for example, mouse serum) as a primary antibody to allow the antibody in the sample to bind to the antigen.

[0075]

Further, as a secondary antibody, an antibody labeled with an enzyme against a mouse antibody is added and is allowed to bind to the mouse antibody. After washing, a substrate for the enzyme is added and a change in absorbance which occurs

due to color development induced by degradation of the substrate or the like is measured and the antibody titer is calculated based on the measurement.

[0076]

The separation of the antibody-producing cells from the spleen cells or lymphocytes of the immunized animal can be carried out according to a known method (for example, Kohler et al., Nature (1975), 256, p. 495; Kohler et al., Eur. J. Immunol. (1977), 6, p. 511; Milstein et al., Nature (1977), 266, p. 550; Walsh, Nature (1977), 266, p. 495). For example, in the case of spleen cells, a general method in which the antibody-producing cells are separated by homogenizing the spleen to obtain the cells through filtration with a stainless steel mesh and suspending the cells in Eagle's Minimum Essential Medium (MEM) can be employed.

[0077]

(c) Preparation of myeloma cells (hereinafter referred to as "myeloma")

The myeloma cells to be used for cell fusion are not particularly limited and suitable cells can be selected from known cell lines. However, in consideration of convenience when a hybridoma is selected from fused cells, it is preferred to use an HGPRT (hypoxanthine-guanine phosphoribosyl transferase) deficient strain whose selection procedure has been established.

[0078]

More specifically, examples of such an HGPRT-deficient strain include X63-Ag8(X63), NS1-ANS/1(NS1), P3X63-Ag8.U1(P3U1), X63-Ag8.653(X63.653), SP2/0-Ag14(SP2/0), MPC11-45.6TG1.7(45.6TG), FO, S149/5XXO, and BU.1 derived from mice; 210.RSY3.Ag.1.2.3(Y3) derived from rats; and U266AR(SKO-007), GM1500·GTG-A12(GM1500), UC729-6, LICR-LOW-HMy2(HMy2) and 8226AR/NIP4-1(NP41) derived from humans. These HGPRT-deficient strains are available from, for example, the American Type Culture Collection (ATCC) or the like.

[0079]

These cell strains are subcultured in an appropriate medium such as an 8-azaguanine medium [a medium obtained by adding 8-azaguanine to an RPMI 1640 medium supplemented with glutamine, 2-mercaptoethanol, gentamicin, and fetal bovine serum (hereinafter referred to as "FBS")], Iscove's Modified Dulbecco's Medium (hereinafter referred to as "IMDM"), or Dulbecco's Modified Eagle Medium (hereinafter referred to as "DMEM"). In this case, 3 to 4 days before performing cell fusion, the cells are subcultured in a normal medium [for example, an ASF104 medium (manufactured by Ajinomoto Co., Ltd.) containing 10% FBS] to ensure not less than 2×10^7 cells on the day of cell fusion.

[0080]

(d) Cell fusion

Fusion between the antibody-producing cells and the myeloma cells can be appropriately performed according to a known method (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, Springfield, Illinois (1964), etc.), under conditions such that the survival rate of cells is not excessively reduced.

[0081]

As such a method, for example, a chemical method in which the antibody-producing cells and the myeloma cells are mixed in a solution containing a polymer such as polyethylene glycol at a high concentration, a physical method using electric stimulation, or the like can be used. Among these methods, a specific example of the chemical method is as described below.

That is, in the case where polyethylene glycol is used in the solution containing a polymer at a high concentration, the antibody-producing cells and the myeloma cells are mixed in a solution of polyethylene glycol having a molecular weight of 1500 to 6000, more preferably 2000 to 4000 at a temperature of from 30 to 40°C, preferably from 35 to 38°C for 1 to 10 minutes, preferably 5 to 8 minutes.

[0082]

(e) Selection of a group of hybridomas

The method of selecting hybridomas obtained by the above-described cell fusion is not particularly limited. Usually, an HAT (hypoxanthine, aminopterin, thymidine) selection method (Kohler et al., Nature (1975), 256, p. 495; Milstein et al., Nature (1977), 266, p. 550) is used.

[0083]

This method is effective when hybridomas are obtained using the myeloma cells of an HGPRT-deficient strain which cannot survive in the presence of aminopterin.

[0084]

That is, by culturing unfused cells and hybridomas in an HAT medium, only hybridomas resistant to aminopterin are selectively allowed to survive and proliferate.

[0085]

(f) Division into single cell clone (cloning)

As a cloning method for hybridomas, a known method such as a methylcellulose method, a soft agarose method, or a limiting dilution method can be used (see, for example, Barbara, B. M. and Stanley, M. S.: Selected Methods in Cellular Immunology, W. H. Freeman and Company, San Francisco (1980)). Among these methods, particularly, a three-dimensional culture method such as a methylcellulose method is preferred. For example, the group of hybridomas produced by cell fusion is suspended in a methylcellulose medium such as ClonaCell-HY Selection Medium D (manufactured by StemCell Technologies,

inc., #03804) and cultured. Then, the formed hybridoma colonies are collected, whereby monoclonal hybridomas can be obtained. The collected respective hybridoma colonies are cultured, and a hybridoma which has been confirmed to have a stable antibody titer in an obtained hybridoma culture supernatant is selected as a B7-H3 monoclonal antibody-producing hybridoma strain.

[0086]

Examples of the thus established hybridoma strain include B7-H3 hybridoma M30. Incidentally, in this specification, an antibody produced by the B7-H3 hybridoma M30 is referred to as "M30 antibody" or simply "M30".

The heavy chain of the M30 antibody has an amino acid sequence represented by SEQ ID NO: 51 in the Sequence Listing. Further, the light chain of the M30 antibody has an amino acid sequence represented by SEQ ID NO: 53 in the Sequence Listing. Incidentally, in the heavy chain amino acid sequence represented by SEQ ID NO: 51 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1 to 19 is a signal sequence, the amino acid sequence consisting of amino acid residues 20 to 141 is a variable region, and the amino acid sequence consisting of amino acid residues 142 to 471 is a constant region. Further, in the light chain amino acid sequence represented by SEQ ID NO: 53 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1

to 22 is a signal sequence, the amino acid sequence consisting of amino acid residues 23 to 130 is a variable region, and the amino acid sequence consisting of amino acid residues 131 to 235 is a constant region.

[0087]

The heavy chain amino acid sequence represented by SEQ ID NO: 51 in the Sequence Listing is encoded by a nucleotide sequence represented by SEQ ID NO: 50 in the Sequence Listing. In the nucleotide sequence represented by SEQ ID NO: 50 in the Sequence Listing, the nucleotide sequence consisting of nucleotides 1 to 57 encodes the heavy chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 58 to 423 encodes the heavy chain variable region of the antibody, and the nucleotide sequence consisting of nucleotides 424 to 1413 encodes the heavy chain constant region of the antibody.

[0088]

The light chain amino acid sequence represented by SEQ ID NO: 53 in the Sequence Listing is encoded by a nucleotide sequence represented by SEQ ID NO: 52 in the Sequence Listing. In the nucleotide sequence represented by SEQ ID NO: 52 in the Sequence Listing, the nucleotide sequence consisting of nucleotides 1 to 66 encodes the light chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 67 to 390 encodes the light chain variable region

of the antibody, and the nucleotide sequence consisting of nucleotides 391 to 705 encodes the light chain constant region of the antibody.

[0089]

(g) Preparation of monoclonal antibody by culturing hybridoma

By culturing the thus selected hybridoma, a monoclonal antibody can be efficiently obtained. However, prior to culturing, it is preferred to perform screening of a hybridoma which produces a target monoclonal antibody.

[0090]

In such screening, a known method can be employed.

[0091]

The measurement of the antibody titer in the invention can be carried out by, for example, an ELISA method explained in item (b) described above.

[0092]

The hybridoma obtained by the method described above can be stored in a frozen state in liquid nitrogen or in a freezer at -80°C or below.

[0093]

After completion of cloning, the medium is changed from an HT medium to a normal medium, and the hybridoma is cultured.

[0094]

Large-scale culture is performed by rotation culture using a large culture bottle or by spinner culture. From the

supernatant obtained by the large-scale culture, a monoclonal antibody which specifically binds to the protein of the invention can be obtained by purification using methods known to those skilled in the art such as gel filtration.

[0095]

Further, the hybridoma is injected into the abdominal cavity of a mouse of the same strain as the hybridoma (for example, the above-described BALB/c) or a Nu/Nu mouse to proliferate the hybridoma, whereby the ascites containing a large amount of the monoclonal antibody of the invention can be obtained.

[0096]

In cases where the hybridoma is administered to the abdominal cavity, if a mineral oil such as 2,6,10,14-tetramethyl pentadecane (pristane) is administered 3 to 7 days prior thereto, a larger amount of the ascites can be obtained.

[0097]

For example, an immunosuppressant is previously injected into the abdominal cavity of a mouse of the same strain as the hybridoma to inactivate T cells. 20 days thereafter, 10^6 to 10^7 hybridoma clone cells are suspended in a serum-free medium (0.5 ml), and the suspension is administered to the abdominal cavity of the mouse. In general, when the abdomen is expanded and filled with the ascites, the ascites is collected from the

mouse. By this method, the monoclonal antibody can be obtained at a concentration which is about 100 times or more higher than that in the culture solution.

[0098]

The monoclonal antibody obtained by the above-described method can be purified by a method described in, for example, Weir, D. M.: Handbook of Experimental Immunology Vol. I, II, III, Blackwell Scientific Publications, Oxford (1978).

[0099]

The thus obtained monoclonal antibody has high antigen specificity for B7-H3.

[0100]

(h) Assay of monoclonal antibody

The isotype and subclass of the thus obtained monoclonal antibody can be determined as follows.

[0101]

First, examples of the identification method include an Ouchterlony method, an ELISA method, and an RIA method.

[0102]

An Ouchterlony method is simple, but when the concentration of the monoclonal antibody is low, a condensation operation is required.

[0103]

On the other hand, when an ELISA method or an RIA method is used, by directly reacting the culture supernatant with an

antigen-adsorbed solid phase and using antibodies corresponding to various types of immunoglobulin isotypes and subclasses as secondary antibodies, the isotype and subclass of the monoclonal antibody can be identified.

[0104]

In addition, as a simpler method, a commercially available identification kit (for example, Mouse Typer Kit manufactured by Bio-Rad Laboratories, Inc.) or the like can also be used.

[0105]

Further, the quantitative determination of a protein can be performed by the Folin Lowry method and a method of calculation based on the absorbance at 280 nm [1.4 (OD 280) = Immunoglobulin 1 mg/ml].

[0106]

Further, even when the monoclonal antibody is separately and independently obtained by performing again the steps of (a) to (h) in (2), it is possible to obtain an antibody having a cytotoxic activity equivalent to that of the M30 antibody. As one example of such an antibody, an antibody which binds to the same epitope as the M30 antibody can be exemplified. The M30 recognizes an epitope in the IgC1 or IgC2 domain, which is a domain in the B7-H3 extracellular domain, and binds to the IgC1 domain or the IgC2 domain or both. Therefore, as the epitope for the M30 antibody, particularly, an epitope present

in the IgC1 or IgC2 domain of B7-H3 can be exemplified. If a newly produced monoclonal antibody binds to a partial peptide or a partial tertiary structure to which the M30 antibody binds, it can be determined that the monoclonal antibody binds to the same epitope as the M30 antibody. Further, by confirming that the monoclonal antibody competes with the M30 antibody for the binding to B7-H3 (that is, the monoclonal antibody inhibits the binding between the M30 antibody and B7-H3), it can be determined that the monoclonal antibody binds to the same epitope as the M30 antibody even if the specific epitope sequence or structure has not been determined. When it is confirmed that the monoclonal antibody binds to the same epitope as the M30 antibody, the monoclonal antibody is strongly expected to have a cytotoxic activity equivalent to that of the M30 antibody.

(3) Other antibodies

The antibody of the invention includes not only the above-described monoclonal antibody against B7-H3 but also a recombinant antibody obtained by artificial modification for the purpose of decreasing heterologous antigenicity to humans such as a chimeric antibody, a humanized antibody and a human antibody. These antibodies can be produced using known methods.

[0107]

As such a chimeric antibody, an antibody in which antibody variable and constant regions are derived from different species, for example, a chimeric antibody in which a mouse- or rat-derived antibody variable region is connected to a human-derived constant region can be exemplified (see Proc. Natl. Acad. Sci. USA, 81, 6851-6855, (1984)). A chimeric antibody derived from a mouse anti-human B7-H3 antibody M30 is an antibody consisting of a heavy chain comprising a heavy chain variable region of which the amino acid sequence consists of amino acid residues 20 to 141 of SEQ ID NO: 51 and a light chain comprising a light chain variable region of which the amino acid sequence consists of amino acid residues 23 to 130 of SEQ ID NO: 53, and may have an arbitrary human-derived constant region. As one example of such a chimeric antibody, an antibody consisting of a heavy chain of which the amino acid sequence consists of amino acid residues 1 to 471 of SEQ ID NO: 63 in the Sequence Listing and a light chain of which the amino acid sequence consists of amino acid residues 1 to 233 of SEQ ID NO: 59 in the Sequence Listing can be exemplified. Incidentally, in the heavy chain sequence represented by SEQ ID NO: 63 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1 to 19 is a signal sequence, the amino acid sequence consisting of amino acid residues 20 to 141 is a variable region, and the amino acid sequence consisting of amino acid residues 142 to 471 is a constant

region. Further, in the light chain sequence represented by SEQ ID NO: 59 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1 to 20 is a signal sequence, the amino acid sequence consisting of amino acid residues 21 to 128 is a variable region, and the amino acid sequence consisting of amino acid residues 129 to 233 is a constant region.

[0108]

The heavy chain amino acid sequence represented by SEQ ID NO: 63 in the Sequence Listing is encoded by a nucleotide sequence represented by SEQ ID NO: 62 in the Sequence Listing. In the nucleotide sequence represented by SEQ ID NO: 62 in the Sequence Listing, the nucleotide sequence consisting of nucleotides 1 to 57 encodes the heavy chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 58 to 423 encodes the heavy chain variable region of the antibody, and the nucleotide sequence consisting of nucleotides 424 to 1413 encodes the heavy chain constant region of the antibody.

[0109]

The light chain amino acid sequence represented by SEQ ID NO: 59 in the Sequence Listing is encoded by a nucleotide sequence represented by SEQ ID NO: 58 in the Sequence Listing. In the nucleotide sequence represented by SEQ ID NO: 58 in the Sequence Listing, the nucleotide sequence consisting of

nucleotides 1 to 60 encodes the light chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 61 to 384 encodes the light chain variable region of the antibody, and the nucleotide sequence consisting of nucleotides 385 to 699 encodes the light chain constant region of the antibody.

[0110]

As such a humanized antibody, an antibody obtained by integrating only a complementarity determining region (CDR) into a human-derived antibody (see Nature (1986) 321, pp. 522-525), and an antibody obtained by grafting a part of the amino acid residues of the framework as well as the CDR sequence to a human antibody by a CDR-grafting method (WO 90/07861) can be exemplified.

[0111]

However, the humanized antibody derived from the M30 antibody is not limited to a specific humanized antibody as long as the humanized antibody has all 6 types of CDR sequences of the M30 antibody and has an antitumor activity. Incidentally, the heavy chain variable region of the M30 antibody has CDRH1 (NYVMH) consisting of the amino acid sequence represented by SEQ ID NO: 92 in the Sequence Listing, CDRH2 (YINPYNDDVKYNEKFKG) consisting of the amino acid sequence represented by SEQ ID NO: 93 in the Sequence Listing, and CDRH3 (WGYYGSPLYYFDY) consisting of the amino acid

sequence represented by SEQ ID NO: 94 in the Sequence Listing. Further, the light chain variable region of the M30 antibody has CDRL1 (RASSRLIYMH) consisting of the amino acid sequence represented by SEQ ID NO: 95 in the Sequence Listing, CDRL2 (ATSNLAS) consisting of the amino acid sequence represented by SEQ ID NO: 96 in the Sequence Listing, and CDRL3 (QQWNSNPPT) consisting of the amino acid sequence represented by SEQ ID NO: 97 in the Sequence Listing.

[0112]

As an example of the humanized antibody of mouse antibody M30, an arbitrary combination of a heavy chain comprising a heavy chain variable region consisting of any one of (1) an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85, 87, 89, or 91 in the Sequence Listing, (2) an amino acid sequence having a homology of at least 95% or more with the amino acid sequence (1) described above, and (3) an amino acid sequence wherein one or several amino acids in the amino acid sequence (1) described above are deleted, substituted or added and a light chain comprising a light chain variable region consisting of any one of (4) an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 71, 73, 75, 77, 79, 81, or 83 in the Sequence Listing, (5) an amino acid sequence having a homology of at least 95% or more with the amino acid sequence (4) described above, and (6) an amino acid sequence wherein one or several amino acids

in the amino acid sequence (4) described above are deleted, substituted or added can be exemplified.

Incidentally, the term “several” as used herein refers to 1 to 10, 1 to 9, 1 to 8, 1 to 7, 1 to 6, 1 to 5, 1 to 4, 1 to 3, or 1 or 2.

As the amino acid substitution in this specification, a conservative amino acid substitution is preferred. The conservative amino acid substitution refers to a substitution occurring within a group of amino acids related to amino acid side chains. Preferred amino acid groups are as follows: an acidic group (aspartic acid and glutamic acid); a basic group (lysine, arginine, and histidine); a non-polar group (alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, and tryptophan); and an uncharged polar family (glycine, asparagine, glutamine, cysteine, serine, threonine, and tyrosine). More preferred amino acid groups are as follows: an aliphatic hydroxy group (serine and threonine); an amide-containing group (asparagine and glutamine); an aliphatic group (alanine, valine, leucine, and isoleucine); and an aromatic group (phenylalanine, tryptophan, and tyrosine). Such an amino acid substitution is preferably performed within a group which does not impair the properties of a substance having the original amino acid sequence.

[0113]

As an antibody which has a preferred combination of a heavy chain and a light

chain described above, an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 71; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 73; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 75; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 77; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ

ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 79; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 81; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence including amino acid residues 20 to 141 of SEQ ID NO: 85 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 83; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 91 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 71; an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 91 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 73; an antibody consisting

of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 91 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 75; and an antibody consisting of a heavy chain comprising a heavy chain variable region consisting of an amino acid sequence consisting of amino acid residues 20 to 141 of SEQ ID NO: 91 and a light chain comprising a light chain variable region consisting of an amino acid sequence consisting of amino acid residues 21 to 128 of SEQ ID NO: 77 can be exemplified. As an antibody which has a more preferred combination of a heavy chain and a light chain described above,

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in

SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 79;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 81;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 83;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in

SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73;

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75; and

an antibody consisting of a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77.

[0114]

Furthermore, as an antibody which has a preferred combination of a heavy chain and a light chain described above, an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 71; an antibody consisting of a heavy chain

comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 73; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 75; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 77; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain

comprising an amino acid sequence of SEQ ID NO: 79; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 81; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 85 and a light chain comprising an amino acid sequence of SEQ ID NO: 83; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 91 and a light chain comprising an amino acid sequence of SEQ ID NO: 71; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 91 and a light chain comprising an amino acid sequence of SEQ ID NO: 73; an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 91 and a light chain comprising an amino acid sequence of SEQ ID NO: 75; and an antibody consisting of a heavy chain comprising an amino acid sequence of SEQ ID NO: 91 and a light chain comprising an amino acid sequence of SEQ ID NO: 77 can be exemplified.

[0115]

By combining a sequence having a high homology with the above-described heavy chain amino acid sequence with a sequence having a high homology with the above-described light chain amino acid sequence, it is possible to select an antibody having a cytotoxic activity equivalent to that of each of the above-described antibodies. Such a homology is generally a homology of 80% or more, preferably a homology of 90% or more,

more preferably a homology of 95% or more, most preferably a homology of 99% or more. Further, by combining an amino acid sequence wherein one to several amino acid residues are substituted, deleted or added in the heavy chain or light chain amino acid sequence, it is also possible to select an antibody having a cytotoxic activity equivalent to that of each of the above-described antibodies.

[0116]

The homology between two amino acid sequences can be determined using default parameters of Blast algorithm version 2.2.2 (Altschul, Stephen F., Thomas L. Madden, Alejandro A. Schäffer, Jinghui Zhang, Zheng Zhang, Webb Miller, and David J. Lipman (1997), "Gapped BLAST and PSI-BLAST: a new generation of protein database search programs", Nucleic Acids Res. 25: 3389-3402). The Blast algorithm can also be used through the Internet by accessing the site 1334907992153_0.

[0117]

Incidentally, in the heavy chain amino acid sequence represented by SEQ ID NO: 85, 87, 89 or 91 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1 to 19 is a signal sequence, the amino acid sequence consisting of amino acid residues 20 to 141 is a variable region, and the amino acid sequence consisting of amino acid residues 142 to 471 is a constant region.

Further, in the light chain amino acid sequence

represented by SEQ ID NO: 71, 73, 75, 77, 79, 81 or 83 in the Sequence Listing, the amino acid sequence consisting of amino acid residues 1 to 20 is a signal sequence, the amino acid sequence consisting of amino acid residues 21 to 128 is a variable region, and the amino acid sequence consisting of amino acid residues 129 to 233 is a constant region.

The heavy chain amino acid sequences represented by SEQ ID NO: 85, 87, 89 or 91 in the Sequence Listing are encoded by nucleotide sequences represented by SEQ ID NO: 84, 86, 88 or 90, respectively, in the Sequence Listing. Further, the sequences represented by SEQ ID NOS: 84 and 85 are shown in Fig. 34, the sequences represented by SEQ ID NOS: 86 and 87 are shown in Fig. 35, the sequences represented by SEQ ID NOS: 88 and 89 are shown in Fig. 36, and the sequences represented by SEQ ID NOS: 90 and 91 are shown in Fig. 37. In each of the above nucleotide sequences, the nucleotide sequence consisting of nucleotides 1 to 57 encodes the heavy chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 58 to 423 encodes the heavy chain variable region of the antibody, and the nucleotide sequence consisting of nucleotides 424 to 1413 encodes the heavy chain constant region of the antibody.

The light chain amino acid sequences represented by SEQ ID NO: 71, 73, 75, 77, 79, 81 or 83 in the Sequence Listing are encoded by nucleotide sequences represented by SEQ ID NO:

70, 72, 74, 76, 78, 80 or 82, respectively, in the Sequence Listing. Further, the sequences represented by SEQ ID NOS: 70 and 71 are shown in Fig. 27, the sequences represented by SEQ ID NOS: 72 and 73 are shown in Fig. 28, the sequences represented by SEQ ID NOS: 74 and 75 are shown in Fig. 29, the sequences represented by SEQ ID NOS: 76 and 77 are shown in Fig. 30, the sequences represented by SEQ ID NOS: 78 and 79 are shown in Fig. 31, the sequences represented by SEQ ID NOS: 80 and 81 are shown in Fig. 32, and the sequences represented by SEQ ID NOS: 82 and 83 are shown in Fig. 33. In each of the above nucleotide sequences, the nucleotide sequence consisting of nucleotides 1 to 60 encodes the light chain signal sequence of the antibody, the nucleotide sequence consisting of nucleotides 61 to 384 encodes the light chain variable region of the antibody, and the nucleotide sequence consisting of nucleotides 385 to 699 encodes the light chain constant region of the antibody.

[0118]

The homology between any of these nucleotide sequences and a nucleotide sequence of another antibody can also be determined using the Blast algorithm.

[0119]

Further, the antibody of the invention includes a human antibody which binds to the same epitope as the M30 antibody. An anti-B7-H3 human antibody refers to a human antibody having

only a gene sequence of an antibody derived from a human chromosome. The anti-B7-H3 human antibody can be obtained by a method using a human antibody-producing mouse having a human chromosome fragment comprising heavy and light chain genes of a human antibody (see Tomizuka, K. et al., Nature Genetics (1997) 16, pp. 133-143; Kuroiwa, Y. et al., Nucl. Acids Res. (1998) 26, pp. 3447-3448; Yoshida, H. et al., Animal Cell Technology: Basic and Applied Aspects vol. 10, pp. 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, pp. 722-727, etc.).

[0120]

Such a human antibody-producing mouse can be created specifically as follows. A genetically modified animal in which endogenous immunoglobulin heavy and light chain gene loci have been disrupted, and instead, human immunoglobulin heavy and light chain gene loci have been introduced via a yeast artificial chromosome (YAC) vector or the like is created by producing a knockout animal and a transgenic animal and mating these animals.

[0121]

Further, according to a recombinant DNA technique, by using cDNAs encoding each of such a heavy chain and a light chain of a human antibody, and preferably a vector comprising such cDNAs, eukaryotic cells are transformed, and a

transformant cell which produces a recombinant human monoclonal antibody is cultured, whereby the antibody can also be obtained from the culture supernatant.

[0122]

Here, as the host, for example, eukaryotic cells, preferably mammalian cells such as CHO cells, lymphocytes, or myeloma cells can be used.

[0123]

Further, a method of obtaining a phage display-derived human antibody selected from a human antibody library (see Wormstone, I. M. et al., Investigative Ophthalmology & Visual Science. (2002) 43 (7), pp. 2301-2308; Carmen, S. et al., Briefings in Functional Genomics and Proteomics (2002), 1 (2), pp. 189-203; Siriwardena, D. et al., Ophthalmology (2002) 109 (3), pp. 427-431, etc.) is also known.

[0124]

For example, a phage display method in which a variable region of a human antibody is expressed on the surface of a phage as a single-chain antibody (scFv), and a phage which binds to an antigen is selected (Nature Biotechnology (2005), 23, (9), pp. 1105-1116) can be used.

[0125]

By analyzing the gene of the phage selected based on its binding to an antigen, a DNA sequence encoding the variable region of a human antibody which binds to an antigen can be

determined.

[0126]

If the DNA sequence of scFv which binds to an antigen is determined, a human antibody can be obtained by preparing an expression vector comprising the sequence and introducing the vector into an appropriate host to express it (WO 92/01047, WO 92/20791, WO 93/06213, WO 93/11236, WO 93/19172, WO 95/01438, WO 95/15388, Annu. Rev. Immunol. (1994) 12, pp. 433-455, Nature Biotechnology (2005) 23 (9), pp. 1105-1116).

[0127]

If a newly produced human antibody binds to a partial peptide or a partial tertiary structure to which the M30 antibody binds, it can be determined that the human antibody binds to the same epitope as the M30 antibody. Further, by confirming that the human antibody competes with the M30 antibody for binding to B7-H3 (that is, the human antibody inhibits the binding between the M30 antibody and B7-H3), it can be determined that the human antibody binds to the same epitope as the M30 antibody even if the specific epitope sequence or structure has not been determined. When it is confirmed that the human antibody binds to the same epitope as the M30 antibody, the human antibody is strongly expected to have a cytotoxic activity equivalent to that of the M30 antibody.

[0128]

The chimeric antibodies, humanized antibodies, or human antibodies obtained by the above-described methods are evaluated for their antigen-binding properties by a method shown in Example 3 or the like, and a preferred antibody can be selected.

[0129]

As one example of another index for use in the comparison of the properties of antibodies, the stability of antibodies can be exemplified. A differential scanning calorimeter (DSC) is a device capable of quickly and accurately measuring a thermal denaturation midpoint temperature (Tm) to be used as a favorable index of the relative conformational stability of proteins. By measuring the Tm values using a DSC and comparing the values, a difference in thermal stability can be compared. It is known that the storage stability of antibodies shows some correlation with the thermal stability of antibodies (Lori Burton, et. al., Pharmaceutical Development and Technology (2007) 12, pp. 265-273), and a preferred antibody can be selected by using thermal stability as an index. Examples of other indices for selecting antibodies include the following features: the yield in an appropriate host cell is high; and the aggregability in an aqueous solution is low. For example, an antibody which shows the highest yield does not always show the highest thermal stability, and therefore, it is necessary to select an antibody most suitable for the administration to

humans by making comprehensive evaluation based on the above-described indices.

[0130]

Further, a method in which the full-length heavy and light chain sequences of an antibody are connected using an appropriate linker, whereby a single-chain immunoglobulin is obtained is also known (Lee, H-S, et. al., Molecular Immunology (1999) 36, pp. 61-71; Shirrmann, T. et. al., mAbs (2010), 2, (1) pp. 1-4). By dimerizing such a single-chain immunoglobulin, the resulting dimer can have a structure and an activity similar to those of an antibody which is a tetramer itself. Further, the antibody of the invention may be an antibody which has a single heavy chain variable region and does not have a light chain sequence. Such an antibody is called a single domain antibody (sdAb) or a nanobody, and in fact, such an antibody is observed in camels and llamas and has been reported to have an antigen-binding affinity (Muyldemans S. et. al., Protein Eng. (1994) 7 (9), 1129-35, Hamers-Casterman C. et. al., Nature (1993) 363 (6428) 446-8). The above-described antibodies can also be construed as a type of functional fragment of the antibody according to the invention.

In the invention, a modified variant of the antibody or a functional fragment of the antibody is also included. The modified variant refers to a variant obtained by subjecting

the antibody or a functional fragment of the antibody of the invention to chemical or biological modification. Examples of such a chemically modified variant include variants chemically modified by linking a chemical moiety to an amino acid skeleton, variants chemically modified with an N-linked or O-linked carbohydrate chain, etc. Examples of such a biologically modified variant include variants obtained by modification after translation (such as N-linked or O-linked glycosylation, N- or C-terminal processing, deamidation, isomerization of aspartic acid, or oxidation of methionine), and variants in which a methionine residue has been added to the N terminus by being expressed in a prokaryotic host cell.

Further, an antibody labeled so as to enable the detection or isolation of the antibody or an antigen of the invention, for example, an enzyme-labeled antibody, a fluorescence-labeled antibody, and an affinity-labeled antibody are also included in the meaning of the modified variant. Such a modified variant of the antibody or a functional fragment of the antibody of the invention is useful for improving the stability and blood retention of the original antibody or a functional fragment of the antibody of the invention, reducing the antigenicity thereof, detecting or isolating such an antibody or an antigen, and so on.

Further, by regulating the modification of a glycan which is linked to the antibody of the invention (glycosylation,

defucosylation, etc.), it is possible to enhanceantibody-dependent cellular cytotoxic activity. As the technique for regulating the modification of a glycan of antibodies, WO 99/54342, WO 00/61739, WO 02/31140, etc. disclose known techniques. However, the technique is not limited thereto. In the antibody and the functional fragment of the antibody of the invention, an antibody or a functional fragment of the antibody in which the modification of a glycan is regulated is also included.

[0131]

In cases where an antibody is produced by first isolating an antibody gene and then introducing the gene into an appropriate host, a combination of an appropriate host and an appropriate expression vector can be used. Specific examples of the antibody gene include a combination of a gene encoding a heavy chain sequence of an antibody and a gene encoding a light chain sequence thereof described in this specification. When a host cell is transformed, it is possible to insert the heavy chain sequence gene and the light chain sequence gene into the same expression vector, and also into different expression vectors separately.

In cases where eukaryotic cells are used as the host, animal cells, plant cells, and eukaryotic microorganisms can be used. As such animal cells, mammalian cells, for example, simian COS cells (Gluzman, Y., Cell, (1981) 23, pp. 175-182,

ATCC CRL-1650), murine fibroblasts NIH3T3 (ATCC No. CRL-1658), and dihydrofolate reductase-deficient strains (Urlaub, G. and Chasin, L. A., Proc. Natl. Acad. Sci. USA (1980) 77, pp. 4126-4220) of Chinese hamster ovarian cells (CHO cells; ATCC: CCL-61) can be exemplified.

In cases where prokaryotic cells are used, for example, Escherichia coli and Bacillus subtilis can be exemplified.

By introducing a gene of a desired antibody or a functional fragment of the antibody into these cells through transformation, and culturing the thus transformed cells in vitro, the antibody can be obtained. In the above-described culture method, the yield may sometimes vary depending on the sequence of the antibody, and therefore, it is possible to select an antibody which is easily produced as a pharmaceutical by using the yield as an index among the antibodies having an equivalent binding activity. Therefore, in the antibody and the functional fragment of the antibody of the invention, an antibody or a functional fragment of the antibody obtained by a method of producing an antibody or a functional fragment of the antibody, characterized by including a step of culturing the transformed host cell and a step of collecting a desired antibody or a functional fragment of the antibody from a cultured product obtained in the culturing step is also included.

Incidentally, it is known that a lysine residue at the

carboxyl terminus of the heavy chain of an antibody produced in a cultured mammalian cell is deleted (Journal of Chromatography A, 705: 129-134 (1995)), and it is also known that two amino acid residues (glycine and lysine) at the carboxyl terminus of the heavy chain of an antibody produced in a cultured mammalian cell are deleted and a proline residue newly located at the carboxyl terminus is amidated (Analytical Biochemistry, 360: 75-83 (2007)). However, such deletion and modification of the heavy chain sequence do not affect the antigen-binding affinity and the effector function (the activation of complement, the antibody-dependent cellular cytotoxicity, etc.) of the antibody. Therefore, in the invention, an antibody and a functional fragment of the antibody subjected to such modification are also included, and a deletion variant in which one or two amino acids have been deleted at the carboxyl terminus of the heavy chain, a variant obtained by amidation of the deletion variant (for example, a heavy chain in which the carboxyl terminal proline residue has been amidated), and the like can be exemplified. The type of deletion variant having a deletion at the carboxyl terminus of the heavy chain of the antibody according to the invention is not limited to the above variants as long as the antigen-binding affinity and the effector function are conserved. The two heavy chains constituting the antibody according to the invention may be of one type selected from

the group consisting of a full-length heavy chain and the above-described deletion variant, or may be of two types in combination selected therefrom. The ratio of the amount of each deletion variant can be affected by the type of cultured mammalian cells which produce the antibody according to the invention and the culture conditions, however, a case where one amino acid residue at the carboxyl terminus has been deleted in both of the two heavy chains contained as main components in the antibody according to the invention can be exemplified. There is no limitation on isotype of the antibody of the invention, and examples thereof include IgG (IgG1, IgG2, IgG3, IgG4), IgM, IgA (IgA1, IgA2), IgD, and IgE, and preferred examples thereof include IgG and IgM, and further more preferred examples thereof include IgG1 and IgG2.

Further, the antibody of the invention may be a functional fragment of the antibody having an antigen-binding site of the antibody or a modified fragment thereof. The fragment of the antibody can be obtained by treating the antibody with a protease such as papain or pepsin, or modifying the antibody gene according to a genetic engineering technique and expressing the modified gene in suitable cultured cells. Among these antibody fragments, a fragment having all or part of the functions of the antibody can be called a functional fragment of the antibody.

As the functions of the antibody, generally

antigen-binding activity, an activity of neutralizing the activity of an antigen, an activity of enhancing the activity of an antigen, antibody-dependent cellular cytotoxicity (ADCC) activity and complement-dependent cytotoxicity (CDC) activity can be exemplified. The function of the antibody and the functional fragment of the antibody according to the invention is a binding activity to B7-H3, preferably antibody-dependent cell-mediated phagocytosis (ADCP) activity, more preferably cytotoxic activity (antitumor activity) mediated by an ADCP activity against tumor cells. Further, the antibody of the invention may have ADCC activity and/or CDC activity in addition to ADCP activity. In particular, it has been reported that a pharmaceutical containing a currently available antitumor antibody directly acts on tumor cells to block a proliferative signal, directly acts on tumor cells to induce a cell death signal, suppresses angiogenesis, induces ADCC activity mediated by NK cells, and induces CDC activity mediated by complement, thereby suppressing the growth of tumor cells (J Clin Oncol 28: 4390-4399. (2010), Clin Cancer Res; 16 (1); 11-20. (2010)), however, at least the present inventors are not aware that the ADCP activity of the anti-B7-H3 antibody according to the invention of this application has been reported as the activity of a pharmaceutical containing a currently available antitumor antibody.

[0132]

Examples of the fragment of the antibody include Fab, F(ab')2, Fv, single-chain Fv (scFv) in which Fv molecules of the heavy chain and the light chain are connected via an appropriate linker, a diabody (diabodies), a linear antibody, and a polyspecific antibody composed of the antibody fragment. Further, Fab' which is a monovalent fragment in a variable region of an antibody obtained by treating F(ab')2 under reducing conditions is also included in the fragment of the antibody.

[0133]

Further, the antibody of the invention may be a polyspecific antibody with specificity for at least two different types of antigens. In general, such an antibody binds to two types of antigens (that is, a bispecific antibody), however, the "polyspecific antibody" as used herein includes an antibody having specificity for two or more (for example, three) types of antigens.

[0134]

The polyspecific antibody of the invention may be a full-length antibody or a fragment of such an antibody (for example, a F(ab')2 bispecific antibody). The bispecific antibody can be produced by connecting the heavy and light chains (HL pairs) of two types of antibodies, or can also be produced by fusing hybridomas which produce different

monoclonal antibodies to prepare bispecific antibody-producing fused cells (Millstein et al., Nature (1983) 305, pp. 537-539).

[0135]

The antibody of the invention may be a single-chain antibody (also referred to as scFv). The single-chain antibody can be obtained by connecting the heavy chain variable region and the light chain variable region of the antibody via a polypeptide linker (Pluckthun, The Pharmacology of Monoclonal Antibodies, 113 (edited by Rosenberg and Moore), Springer Verlag, New York, pp. 269-315 (1994), Nature Biotechnology (2005), 23, pp. 1126-1136). Further, a BiscFv fragment produced by connecting two scFv molecules via a polypeptide linker can also be used as the bispecific antibody.

[0136]

A method of producing a single-chain antibody is known in this technical field (see, for example, US patent Nos. 4,946,778, 5,260,203, 5,091,513, 5,455,030, etc.). In this scFv, the heavy chain variable region and the light chain variable region are connected via a linker which does not form a conjugate, preferably via a polypeptide linker (Huston, J. S. et al., Proc. Natl. Acad. Sci. USA (1988), 85, pp. 5879-5883). In the scFv, the heavy chain variable region and the light chain variable region may be derived from the same antibody or different antibodies.

As the polypeptide linker to be used for connecting the variable regions, for example, a given single-chain peptide consisting of 12 to 19 residues is used.

[0137]

A DNA encoding an scFv can be obtained by performing amplification through PCR using a DNA as a template that comprises all or desired part of a DNA selected from a DNA encoding the heavy chain or the heavy chain variable region of the above-described antibody and a DNA encoding the light chain or the light chain variable region thereof and also using a primer pair that defines both ends of the template DNA, and further performing amplification by combining a DNA encoding a polypeptide linker portion and a primer pair that defines both ends of the polypeptide so as to connect said both ends thereof to each of the heavy chain and the light chain.

[0138]

Further, once DNA encoding an scFv is produced, an expression vector comprising the same and a host transformed by the expression vector can be obtained according to common procedures. Further, by using the resulting host, an scFv can be obtained according to common procedures. An antibody fragment thereof can be produced in a host by obtaining a gene and expressing the gene in the same manner as described above.

[0139]

The antibody of the invention may be multimerized to

increase its affinity for an antigen. The antibody to be multimerized may be one type of antibody or plural antibodies which recognize plural epitopes of the same antigen. As a method of multimerization of the antibody, binding of the IgG CH3 domain to two scFv molecules, binding to streptavidin, introduction of a helix-turn-helix motif, and the like can be exemplified.

[0140]

The antibody of the invention may be a polyclonal antibody which is a mixture of plural types of anti-B7-H3 antibodies having different amino acid sequences. As one example of the polyclonal antibody, a mixture of plural types of antibodies having different CDR can be exemplified. As such a polyclonal antibody, antibodies obtained by culturing a mixture of cells which produce different antibodies and then purifying the antibodies from the resulting culture can be used (see WO 2004/061104).

[0141]

As a modified antibody, an antibody bound to any of various types of molecules such as polyethylene glycol (PEG) can also be used.

[0142]

Further, the antibody of the invention may be in the form of a conjugate formed between any of these antibodies and another medicinal agent (immunoconjugate). Examples of such

an antibody include a conjugate in which the antibody is conjugated to a radioactive material or a compound having a pharmacological action (Nature Biotechnology (2005) 23, pp. 1137-1146). Examples thereof include indium (^{111}In)-capromab pendetide, technetium (^{99m}Tc)-nofetumomab merpentan, indium (^{111}In)-ibritumomab, yttrium (^{90}Y)-ibritumomab, and iodine (^{131}I)-tositumomab.

[0143]

The obtained antibody can be purified to homogeneity. The separation and purification of the antibody may be performed employing a conventional protein separation and purification method. For example, the antibody can be separated and purified by appropriately selecting and combining column chromatography, filter filtration, ultrafiltration, salt precipitation, dialysis, preparative polyacrylamide gel electrophoresis, isoelectric focusing electrophoresis, and the like (Strategies for Protein Purification and Characterization: A Laboratory Course Manual, Daniel R. Marshak et al. eds., Cold Spring Harbor Laboratory Press (1996); Antibodies: A Laboratory Manual. Ed Harlow and David Lane, Cold Spring Harbor Laboratory (1988)), but the method is not limited thereto.

[0144]

Examples of such chromatography include affinity chromatography, ion exchange chromatography, hydrophobic

chromatography, gel filtration chromatography, reverse phase chromatography, and adsorption chromatography.

Such chromatography can be performed employing liquid chromatography such as HPLC or FPLC.

[0145]

As a column to be used in affinity chromatography, a Protein A column and a Protein G column can be exemplified. For example, as a column using a Protein A column, Hyper D, POROS, Sepharose FF (Pharmacia) and the like can be exemplified.

Further, by using a carrier having an antigen immobilized thereon, the antibody can also be purified utilizing the binding property of the antibody to the antigen.

3. Pharmaceutical comprising anti-B7-H3 antibody

The antibodies obtained by the method described in the above item "2. Production of anti-B7-H3 antibody" exhibit a cytotoxic activity against cancer cells, and therefore can be used as a pharmaceutical, particularly a therapeutic agent and/or preventive agent for cancer.

[0146]

Thecytotoxic activity exhibited by an antibody in vitro can be determined by measuring the inhibitory activity of cell growth.

[0147]

For example, a cancer cell line which overexpresses B7-H3 is cultured, an antibody is added to the culture system at different concentrations, and any inhibitory activity against focus formation, colony formation, and spheroid growth can be measured.

[0148]

The in vivo therapeutic effect of an antibody on cancer using experimental animals can be determined by, for example, administering the antibody to nude mice implanted with a tumor cell line which overexpresses B7-H3 and measuring any change in the cancer cells.

[0149]

Examples of the type of cancer include lung cancer, kidney cancer, urothelial carcinoma, colorectal cancer, prostate cancer, glioblastoma multiforme, ovarian cancer, pancreatic cancer, breast cancer, a melanoma, liver cancer, bladder cancer, stomach cancer, and esophageal cancer, however, the type of cancer is not limited thereto as long as the cancer cell to be treated expresses B7-H3.

[0150]

An acceptable substance to be used in the preparation of the pharmaceutical composition according to the invention is preferably non-toxic to a individual to whom the pharmaceutical composition is to be administered in terms of the dose and concentration.

[0151]

The pharmaceutical composition of the invention can comprise a substance for pharmaceutical use which is capable of changing or maintaining the pH, osmotic pressure, viscosity, transparency, color, isotonicity, aseptic condition, stability, solubility, release rate, absorption rate, and permeability thereof. Examples of such a substance for pharmaceutical use include, but are not limited to, amino acids such as glycine, alanine, glutamine, asparagine, arginine, and lysine; antimicrobial agents; antioxidants such as ascorbic acid, sodium sulfate, and sodium hydrogen sulfite; buffers such as phosphate, citrate, borate buffers, sodium hydrogen carbonate, and Tris-HCl solutions; fillers such as mannitol and glycine; chelating agents such as ethylenediamine tetraacetate (EDTA); complexing agents such as caffeine, polyvinylpyrrolidine, β-cyclodextrin, and hydroxypropyl-β-cyclodextrin; expanders such as glucose, mannose, and dextrin; other carbohydrates such as monosaccharides and disaccharides; coloring agents; flavors; diluents; emulsifying agents; hydrophilic polymers such as polyvinylpyrrolidine; preservatives such as low-molecular weight polypeptides, salt-forming counter ions, 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 sorbitan ester, polysorbates including polysorbate 20 and polysorbate 80, Triton, tromethamine, lecithin, and cholesterol; stability enhancing agents such as sucrose and sorbitol; elasticity enhancing agents such as sodium chloride, potassium chloride, and mannitol and sorbitol; transport agents; excipients; and/or pharmaceutical adjuvants. The amount of these substances for pharmaceutical use is preferably from 0.001 to 100 times, particularly preferably from 0.1 to 10 times the weight of the anti-B7-H3 antibody. Those skilled in the art can appropriately determine a preferred formulation of the pharmaceutical composition in a preparation depending on the disease to which the composition is applied, the route of administration to be applied, or the like.

[0152]

The excipient or carrier in the pharmaceutical composition may be in the form of a liquid or a solid. An appropriate excipient or carrier may be injectable water, physiological saline, an artificial cerebrospinal fluid, or other substance commonly used for parenteral administration. Further, neutral physiological saline or physiological saline containing serum albumin can also be used as a carrier. The pharmaceutical composition may contain a Tris buffer of pH 7.0 to 8.5, an acetate buffer of pH 4.0 to 5.5, or a citrate buffer

of pH 3.0 to 6.2. Further, such a buffer may be supplemented with sorbitol or another compound.

[0153]

Examples of the pharmaceutical composition of the invention include a pharmaceutical composition comprising the anti-B7-H3 antibody and a pharmaceutical composition comprising the anti-B7-H3 antibody and at least one therapeutic agent for cancer. The pharmaceutical composition of the invention is prepared in the form of a lyophilized product or a liquid as a medicinal agent having a selected composition and a required purity. The pharmaceutical composition comprising the anti-B7-H3 antibody and the pharmaceutical composition comprising the anti-B7-H3 antibody and at least one therapeutic agent for cancer can also be formed into a lyophilized product using an appropriate excipient such as sucrose.

[0154]

In the above-described pharmaceutical composition, the therapeutic agent for cancer to be incorporated along with the anti-B7-H3 antibody may be administered simultaneously with, separately from, or sequentially with the anti-B7-H3 antibody, or the therapeutic agent and the anti-B7-H3 antibody may be administered at different dosage intervals. Examples of such a therapeutic agent for cancer include abraxane, carboplatin, cisplatin, gemcitabine, irinotecan (CPT-11), paclitaxel,

pemetrexed, sorafenib, vinblastin, and medicinal agents described in WO 2003/038043, and additional examples thereof include LH-RH analogues (such as leuprorelin and goserelin), estramustine phosphate, estrogen antagonists (such as tamoxifen and raloxifene), and aromatase inhibitors (such as anastrozole, letrozole, and exemestane), however, the agent is not limited thereto as long as the agent is a medicinal agent having an antitumor activity.

An individual to whom the pharmaceutical composition is to be administered is not particularly limited, however, preferred are mammals, and more preferred are humans.

[0155]

The pharmaceutical composition of the invention can be prepared for parenteral administration or for gastrointestinal absorption through oral administration. The composition and concentration of a preparation can be determined depending on the administration method. The higher the affinity of the anti-B7-H3 antibody comprised in the pharmaceutical composition of the invention is for B7-H3, that is, the lower the dissociation constant (Kd value) thereof is for B7-H3, the more the anti-B7-H3 antibody can exhibit its drug efficacy even when decreasing the dose for humans. Hence, the dose of the pharmaceutical composition of the invention for humans can also be determined based on this result. As for the dose, in the case where a human anti-B7-H3 antibody

is administered to humans, the antibody may be administered at a dose of from about 0.001 to 100 mg/kg once or several times at intervals of 1 to 180 days. Examples of the dosage form of the pharmaceutical composition of the invention include injections including infusions, suppositories, transnasal agents, sublingual agents, and percutaneous absorbents.

[0156]

Examples

[0157]

Hereinafter, the invention will be described in more detail with reference to the Examples, however, the invention is not limited thereto.

[0158]

Note that the respective operations regarding gene

manipulation in the following Examples were performed according to the methods described in "Molecular Cloning" (written by Sambrook, J., Fritsch, E. F. and Maniatis, T., published by Cold Spring Harbor Laboratory Press in 1989), or in the case of using commercially available reagents or kits, they are used according to the instructions attached thereto unless otherwise stated.

Example 1. Production of plasmid

1)-1 Production of human B7-H3 expression vector

1)-1-1 Production of expression vector for full-length human B7-H3 variant 1

A PCR reaction was performed using a cDNA synthesized from the total RNA of LNCaP cells (American Type Culture Collection (ATCC)) as a template and also using the following primer set, thereby amplifying a cDNA encoding the human B7-H3 variant 1:

Primer 1:

5'-ctatagggagacccaagctggctagcatgctgcgtcggcggggcag-3' (SEQ ID NO: 1 in the Sequence Listing); and

Primer 2:

5'-aacgggccctctagactcgagcggccgctcaggctatttcttgtccatcatcttc tttgctgtcag-3' (SEQ ID NO: 2 in the Sequence Listing).

Subsequently, the thus obtained PCR product was purified using MagExtractor PCR & Gel cleanup (TOYOBO, Co., Ltd.). Then,

the PCR product was digested with restriction enzymes (NheI and NotI), followed by purification using MagExtractor PCR & Gel cleanup (TOYOBO, Co., Ltd.). A pcDNA3.1(+) plasmid DNA was digested with the same restriction enzymes (NheI and NotI), followed by purification using MagExtractor PCR & Gel cleanup (TOYOBO, Co., Ltd.).

The resulting purified DNA solutions were mixed, and further, Ligation high (TOYOBO, Co., Ltd.) was added thereto, and the resulting mixture was incubated at 16°C for 8 hours to effect ligation. The resulting reaction mixture was added to E. coli DH5α competent cells (Invitrogen Corporation) to effect transformation.

Colony direct PCR was performed on the resulting colonies using the PCR primers and the BGH reverse primer, and a candidate clone was selected.

The obtained candidate clone was cultured in a liquid medium (LB/Amp), and a plasmid DNA was extracted using MagExtractor -Plasmid- (TOYOBO, Co., Ltd.).

By using the obtained plasmid DNA as a template, a sequence between the following Primer 3 and Primer 4 was determined by sequence analysis and the sequences were compared between the obtained clone and the provided CDS sequence:

Primer 3 (CMV promoter primer):

5'-cgcaaatgggcggtaggcgtg-3' (SEQ ID NO: 3 in the Sequence Listing); and

Primer 4 (BGH reverse primer):

5′-tagaaggcacagtcgagg-3′ (SEQ ID NO: 4 in the Sequence Listing).

After confirming the sequence, the obtained clone was cultured in 200 ml of LB/Amp medium, and a plasmid DNA was extracted using Plasmid Midi V-100 kit (VioGene, Inc.).

The thus obtained vector was named "pcDNA3.1-B7-H3". The sequence of the ORF region of the B7-H3 variant 1 gene cloned in this vector is represented by nucleotide numbers 1 to 1602 in SEQ ID NO: 5 in the Sequence Listing. Further, the amino acid sequence of the B7-H3 variant 1 is represented by SEQ ID NO: 6 in the Sequence Listing.

1)-1-2 Production of expression vector for full-length human B7-H3 variant 2

PCR was performed using a cDNA synthesized from the total RNA of LNCaP cells as a template and also using the following primer set, thereby amplifying a cDNA encoding the human B7-H3 variant 2:

Primer 5

5′-ggggacaagtttgtacaaaaaagcaggcttcaccatgctgcgtcggcggggcagccctg-3′ (SEQ ID NO: 7 in the Sequence Listing)

Primer 6

5′-ggggaccactttgtacaagaaagctgggtcggctatttcttgt-3′ (SEQ ID NO: 8 in the Sequence Listing).

[0159]

Purification was performed in the same manner as in Example 1)-1-1, and the PCR product after purification was integrated into a pDONR221 vector (Invitrogen Corporation) by a Gateway BP reaction, thereby transforming E. coli TOP10 (Invitrogen Corporation).

For the clones obtained after transformation, the size of the insert was confirmed by colony PCR. For 8 clones in which the size of the insert was confirmed, the DNA sequence at the 3′ end and the 5′ end of the insert was confirmed by performing one sequencing reaction from the vector side to the insert side for both ends. A Gateway LR reaction between the entry clone whose sequence was confirmed and a Gateway destination vector pcDNA-DEST40 (Invitrogen Corporation) was performed. For the clone obtained after transformation of E. coli TOP10, the size of the insert was confirmed by colony PCR. For the clone in which the size of the insert was confirmed, the DNA sequence at the 3′ end and the 5′ end of the insert was analyzed to confirm that the insert of interest was correctly inserted. At least 1 mg of the thus produced plasmid of the clone was purified using PureLink HiPure Plasmid Megaprep Kit (Invitrogen Corporation).

The thus obtained vector was named “pcDNA-DEST40-B7-H3 variant 2”. The sequence of the ORF region of the B7-H3 variant 2 gene cloned in this vector is represented by nucleotide

numbers 1 to 948 in SEQ ID NO: 9 in the Sequence Listing. Further, the amino acid sequence of the B7-H3 variant 2 is represented by SEQ ID NO: 10 in the Sequence Listing.

1)-2 Production of expression vector for B7-H3 partial protein

By using the B7-H3 full-length plasmid related to the B7-H3 variant 1 of Example 1)-1-1 as a template, each of the following regions was amplified by PCR. The numbers showing each region of interest correspond to the nucleotide numbers of B7-H3 represented by SEQ ID NO: 5. The primer was designed to contain a stop codon at the 3' end in addition to the Gateway att sequence.

Each of the following regions 1), 2), and 3) was prepared by amplifying two regions and then ligating the regions by PCR to form one fragment. That is, as for region 1), amplification was performed using Primers 7 and 12, and Primers 15 and 11, and the resulting PCR products were further amplified using Primers 7 and 11. As for region 2), amplification was performed using Primers 8 and 13, and Primers 15 and 11, and the resulting PCR products were further amplified using Primers 8 and 11. As for region 3), amplification was performed using Primers 9 and 14, and Primers 15 and 11, and the resulting PCR products were further amplified using Primers 9 and 11. As for region 4), amplification was performed using Primers 10 and 11. As for region 5), amplification was performed using Primers 8 and

11. As for region 6), amplification was performed using Primers 9 and 11.

Regions of interest

1) B7-H3 variant 1 ORF: 79-417 and 1369-1602 (573 bp)

2) B7-H3 variant 1 ORF: 418-732 and 1369-1602 (549 bp)

3) B7-H3 variant 1 ORF: 733-1071 and 1369-1602 (573 bp)

4) B7-H3 variant 1 ORF: 1072-1602 (531 bp)

5) B7-H3 variant 1 ORF: 418-1602 (1185 bp)

6) B7-H3 variant 1 ORF: 733-1602 (870 bp)

Primer number and base sequence

Primer 7

5′-ggggacaagtttgtacaaaaaagcaggcttcggagccctggaggtccaggtc-3′ (SEQ ID NO: 11 in the Sequence Listing)

Primer 8

5′-ggggacaagtttgtacaaaaaagcaggcttcgctccctactcgaagcccagcatg-3′ (SEQ ID NO: 12 in the Sequence Listing)

Primer 9

5′-ggggacaagtttgtacaaaaaagcaggcttcggagccgtggaggtccaggtc-3′ (SEQ ID NO: 13 in the Sequence Listing)

Primer 10

5′-ggggacaagtttgtacaaaaaagcaggcttcgctccctactcgaagcccagcatg-3′ (SEQ ID NO: 14 in the Sequence Listing)

Primer 11

5′-ggggaccactttgtacaagaaagctgggtctcaggctatttcttgtccatcatc-3′ (SEQ ID NO: 15 in the Sequence Listing)

Primer 12

5′-gggaatgtcataggctgcccggccacctgcaggctgacggcag-3′ (SEQ ID NO: 16 in the Sequence Listing)

Primer 13

5′-gggaatgtcataggctgccctgtggggcttctctggggtgtg-3′ (SEQ ID NO: 17 in the Sequence Listing)

Primer 14

5′-gggaatgtcataggctgcccggccacctgcaggctgacggcag-3′ (SEQ ID NO: 18 in the Sequence Listing)

Primer 15

5′-gggcagcctatgacattccccccagag-3′ (SEQ ID NO: 19 in the Sequence Listing)

Purification was performed in the same manner as in Example 1)-1-1, and each of the amplified products after purification was integrated into a pDONR221 vector by a Gateway BP reaction, thereby transforming E. coli TOP10. For the clones obtained after transformation, the size of the insert was confirmed by colony PCR.

For each of the clones in which the size of the insert was confirmed, the DNA sequence at the 3′ end and the 5′ end of the insert was confirmed by performing one sequencing reaction from the vector side to the insert side for both ends.

For the clones which were confirmed to have the insert

of interest, the total DNA sequence of the insert was also confirmed using the following primers. As a result of sequence analysis, it was confirmed that all of the sequences were completely identical to the information of the sequences of interest.

A Gateway LR reaction between each of the entry clones whose sequence was confirmed and pFLAG-myc-CMV-19-DEST (Invitrogen Corporation) was performed. For the clones obtained after transformation of E. coli DH10B (Invitrogen Corporation), the size of the insert was confirmed by colony PCR.

For each of the clones in which the size of the insert was confirmed, the DNA sequence at the 3' end and the 5' end of the insert was analyzed to confirm that the insert of interest was correctly inserted. Hereinafter, the expression vectors obtained by integrating each of the above regions 1) to 6) were represented by "B7-H3 IgV1", "B7-H3 IgC1", "B7-H3 IgV2", "B7-H3 IgC2", "B7-H3 IgC1-V2-C2", and "B7-H3 IgV2-C2", respectively.

The nucleotide sequences of the ORF regions of the B7-H3 IgV1, B7-H3 IgC1, B7-H3 IgV2, B7-H3 IgC2, B7-H3 IgC1-V2-C2, and B7-H3 IgV2-C2 genes, each of which was cloned in this vector, are represented by SEQ ID NOS: 20, 22, 24, 26, 28, and 30, respectively, in the Sequence Listing. Further, the amino acid sequences of the B7-H3 IgV1, B7-H3 IgC1, B7-H3 IgV2, B7-H3

IgC2, B7-H3 IgC1-V2-C2, and B7-H3 IgV2-C2 are represented by SEQ ID NOS: 21, 23, 25, 27, 29, and 31, respectively, in the Sequence Listing. Further, the sequences represented by SEQ ID NOS: 20 and 21 are shown in Fig. 15, the sequences represented by SEQ ID NOS: 22 and 23 are shown in Fig. 16, the sequences represented by SEQ ID NOS: 24 and 25 are shown in Fig. 17, the sequences represented by SEQ ID NOS: 26 and 27 are shown in Fig. 18, the sequences represented by SEQ ID NOS: 28 and 29 are shown in Fig. 19, and the sequences represented by SEQ ID NOS: 30 and 31 are shown in Fig. 20.

1)-3 Production of expression vectors for B7 family genes

pCMV6-XL-4-B7RP-1, pCMV6-XL-4-B7-H1, and pCMV6-XL-4-B7-DC (which are gene expression vectors obtained by integrating each of B7RP-1, B7-H1, and B7-DC (which are B7 family genes) in an expression vector pCMV6-XL-4) were all purchased from OriGene, Inc.

[0160]

Vectors expressing each of CD80, CD86, and B7-H4, which are B7 family genes, were produced as follows.

pENTR/221-CD80, pENTR/221-CD86, and pENTR/221-B7-H4, which are clones obtained by integrating each of CD80, CD86, and B7-H4 in an entry vector pENTR/221, were purchased from Invitrogen Corporation

A Gateway LR reaction between each of the entry clones

whose sequence was confirmed and pcDNA3.1-DEST (Invitrogen Corporation) was performed. For the clones obtained after transformation of E. coli DH10B, the size of the insert was confirmed by colony PCR. For each of the clones in which the size of the insert was confirmed, the DNA sequence at the 3' end and the 5' end of the insert was analyzed to confirm that the insert of interest was correctly inserted.

The nucleotide sequences of the ORF regions of the B7RP-1, B7-H1, B7-DC, CD80, CD86, and B7-H4 genes, each of which was cloned in this vector, are represented by SEQ ID NOS: 32, 34, 36, 38, 40, and 42, respectively, in the Sequence Listing. Further, the amino acid sequences of the B7RP-1, B7-H1, B7-DC, CD80, CD86, and B7-H4 are represented by SEQ ID NOS: 33, 35, 37, 39, 41, and 43, respectively, in the Sequence Listing.

Example 2. Production of monoclonal antibody and screening of antibody

2)-1 Immunization

BALB/cAnNCrlCrlj mice (Charles River Laboratories Japan, Inc.), FcgRII KO mice (Taconic, Inc., IBL Co., Ltd.), or GANP mice (Transgenic, Inc.) at 4 to 6 weeks of age were used. On days 0, 7, 15, and 24, LNCaP cells, MCF7 cells (ATCC) or AsPC1 cells (ATCC) detached with versene (Invitrogen Corporation) were subcutaneously administered to the dorsal region of each mouse at a dose of 5×10^6 cells/mouse. On day 31, the same

cells were intravenously administered to each mouse at a dose of 5 x 10^6 cells. On day 34, the spleen was excised from each mouse and used for the production of hybridomas.

2)-2 Production of hybridomas

Spleen cells and mouse myeloma P3X63Ag8U.1 cells (ATCC) were subjected to cell fusion using PEG 4000 (manufactured by IBL Co., Ltd.), thereby producing hybridomas.

[0161]

As a result, 9639 clones from the mice immunized with LNCaP cells, 4043 clones from the mice immunized with MCF7 cells, and 3617 clones from the mice immunized with AsPC1 cells were established as hybridomas. By using the obtained culture supernatant of each hybridoma, an antibody-producing hybridoma was screened by a CDC assay.

2)-3 Screening of antibody by CDC assay

On day 0, LNCaP cells or MCF7 cells were diluted to 5000 cells per 80 μL and the resulting solution was added to a 96-well plate at 80 μl/well. Then, the cells were cultured overnight. The hybridoma culture supernatant was added at 20 μl/well to the plate in which the cells were seeded, and the plate was left to stand at 4°C for 1 hour. To a diluted and lyophilized rabbit complement (Cedarlane Laboratories), 1 mL of sterile water was added to each vial on ice, and the vial was left to

stand for 1 minute, followed by mixing, and then the resulting mixture was mixed with 19 mL of 0.1% BSA/RPMI 1640 medium (BSA, Sigma Co., Ltd.). A reaction was allowed to proceed at 37°C for 1 hour.

[0162]

The plate was left at room temperature for 30 minutes to return to room temperature. 120 μL of CellTiter-Glo reagent (Promega Corporation) was added to each well, and a reaction was allowed to proceed at room temperature for 10 minutes. The amount of luminescence was measured using a plate reader (ARVO HTS, PerkinElmer, Inc.). In a well exhibiting low luminescence, it was determined that complement-dependent cell death was induced. A hybridoma which produced a culture supernatant that induced such complement-dependent cell death was selected.

As a result, 24 clones from the clones derived from immunization with LNCaP, 36 clones from the clones derived from immunization with MCF7, and 3 clones from the clones derived from immunization with AsPC1 were obtained as positive clones by screening.

Example 3. Identification of antigen

3)-1 Identification of immunoprecipitated substance

3)-1-1 Immunoprecipitation

MCF7 cells were cultured at 5 to 10 x 10^8 cells. These

cells were detached with a cell scraper and the detached cells were collected and cryopreserved at -80°C. To the cryopreserved cells, 10 ml of a lysis buffer which contained 1% NP-40 (Sigma-Aldrich Co., Ltd.) and a protease inhibitor (F. Hoffmann-La Roche, Ltd.) and was cooled to 4°C was added and the cell pellet was lysed on ice with a pipette in such a manner that the formation of bubbles was avoided. After being completely lysed, the pellet was left on ice for 30 minutes. The solubilized sample was centrifuged at 4°C for 20 minutes at 10000 to 15000 rpm, and the resulting supernatant was transferred to a 15 ml Falcon tube.

500 μl of protein G-Sepharose 4FF beads (Amersham Pharmacia Biotech Co., Ltd.) were washed three times, and subjected to buffer exchange with a lysis buffer. 500 μl of the protein G-Sepharose 4FF beads were added to the solubilized sample supernatant on ice, and the resulting mixture was subjected to rotary stirring overnight at 4°C.

The sample was passed through Poly-Prep chromatography columns (Bio-Rad Laboratories, Inc.), and a passed-through fraction was used as an immunoprecipitation sample.

3 μg of an antibody solution to be used for immunoprecipitation was added to 50 μl of protein G-Sepharose 4FF beads subjected to buffer exchange with phosphate buffered saline (PBS) (a 1.5 ml tube), and the resulting mixture was subjected to rotary stirring at 4°C for 1 to 16 hours, whereby

the antibody was bound to the beads. To the immunoprecipitation sample, the beads to which the antibody was bound were added, and the resulting mixture was subjected to rotary stirring at 4°C for 3 hours.

The column was transferred to an empty 15 ml Falcon tube, and 6.5 ml of a lysis buffer was added thereto. This procedure was repeated 4 times.

The outlet of the column was capped, and pipetting was performed with 500 μl of a lysis buffer, and the beads were collected in a 1.5 ml tube. This procedure was repeated twice.

After centrifugation at 4°C for 1 minute at 5000 rpm, the supernatant was carefully removed. Then, 90 μl of an elution buffer (10 mM glycine-HCl, pH 2.0) was added thereto, followed by vortexing and centrifugation. The column of 1.5 ml spin column was detached, and 10 μl of 1 M Tris-HCl (pH 8.5) was added thereto, and the column was returned to the original place. An elution fraction was transferred thereto, and centrifugation was performed at 10000 rpm for 1 minute, whereby 100 μl of a sample was obtained.

The obtained sample was subjected to MS analysis by a liquid phase digestion technique as shown in the following 3)-1-2.

3)-1-2 Identification of antigen by mass spectrometry analysis

According to common procedures, the fraction obtained

by the immunoprecipitation method was subjected to a digestion reaction at 37°C for 16 hours by adding trypsin (modified trypsin, Promega Corporation) through a liquid phase digestion technique. The resulting digested peptides were subjected to a liquid chromatography (LC)/tandem mass spectrometer (MS/MS) (Thermo Fisher Scientific K.K.). The obtained mass spectral data were analyzed using database search software (Mascot, Matrix Science K.K.). As the database, International Protein Index (IPI) was used. As a result, 34 types of antigens were identified.

From the characteristics of the identified antigens, bibliographic information retrieval was performed based on which B7-H3 is a cell membrane protein, and by focusing on B7-H3 (CD276) antigen (B7-H3 variant 1), the experiments described in the following 3)-2 and 3)-3 were performed.

3)-2 Preparation of antigen gene-expressing cells

NIH-3T3 cells (ATCC) were seeded at 5 x 10^4 cells/cm^2 in a collagen type I-coated flask (manufactured by IWAKI Co., Ltd.) and cultured overnight in DMEM medium (Invitrogen Corporation) containing 10% fetal bovine serum (FBS) under the conditions of 37°C and 5% CO_2.

On the next day, the NIH-3T3 cells were transfected with each of the pcDNA3.1-B7-H3 produced in Example 1)-1-1, pcDNA-DEST40-B7-H3 variant 2 produced in 1)-1-2, and

pcDNA-DEST40 which is an empty vector using Lipofectamine 2000 (Invitrogen Corporation), and further cultured overnight under the conditions of 37°C and 5% CO_2.

On the next day, the transfected NIH-3T3 cells were treated with trypsin, and washed with DMEM containing 10% FBS, and thereafter suspended in PBS containing 5% FBS. The thus obtained cell suspension was used in a flow cytometric analysis.

3)-3 Flow cytometric analysis

The binding specificity, for B7-H3, of the antibody produced by the hybridoma which immunoprecipitated the B7-H3 variant 1 identified by MS was confirmed by a flow cytometric method. The cell suspension prepared in Example 3)-2 was centrifuged, and the supernatant was removed. Then, the hybridoma culture supernatant was added to the NIH-3T3 cells transfected with each vector to suspend the cells, and the cells were left to stand at 4°C for 1 hour.

After the cells were washed twice with PBS containing 5% FBS, fluorescein-conjugated goat IgG fraction to mouse IgG (whole molecule) (manufactured by ICN Pharmaceuticals, Inc., #55493) diluted to 1000-fold with PBS containing 5% FBS was added thereto to suspend the cells, and the cells were left to stand at 4°C for 1 hour.

After the cells were washed twice with PBS containing

5% FBS, the cells were resuspended in PBS containing 5% FBS supplemented with 2 μg/ml 7-aminoactinomycin D (manufactured by Invitrogen Corporation (Molecular Probes)), and the detection was performed using a flow cytometer (FC500, Beckman Coulter, Inc.). The data was analyzed using Flowjo (Tree Star, Inc.).

7-Aminoactinomycin D-positive dead cells were excluded using a gate. Then, the FITC fluorescence intensity histograms of viable cells were created.

A hybridoma which produced a sample that gave a higher fluorescence intensity in the fluorescence intensity histograms of the NIH-3T3 cells expressing the B7-H3 variant 1 and the NIH-3T3 cells expressing the B7-H3 variant 2 than in the fluorescence intensity histogram of the NIH-3T3 cells transfected with the empty vector serving as the control was selected as an anti-B7-H3 antibody-producing hybridoma.

[0163]

As a result, it was found that the antibodies derived from the anti-B7-H3 antibody-producing hybridomas of 5 clones (L7, L8, L11, M30, and M31) have cross-reactivity with the B7-H3 variant 1 and the B7-H3 variant 2.

3)-4 Confirmation of binding property of monoclonal antibody to cancer cell line

It was examined as to whether the monoclonal antibodies

confirmed to bind to the B7-H3 variant 1 and the B7-H3 variant 2 in Example 3)-3 bind to cancer cells which overexpress the B7-H3 variant 1 and the B7-H3 variant 2 by a flow cytometric method in the same manner as in Example 3)-3.

In place of the transfected NIH-3T3 cells, a human breast cancer cell line (MDA-MB-231) (ATCC) and a human lung cancer cell line (NCI-H322) (ATCC) were used. As a result, it was confirmed that the established monoclonal antibodies all bind to these cancer cell lines.

3)-5 Isotype determination of monoclonal antibody

The isotypes of the monoclonal antibodies were determined using a Mouse monoclonal isotyping kit (manufactured by Serotec Co., Ltd.). As a result, the isotypes of the antibodies derived from the anti-B7-H3 antibody-producing hybridomas (L7, L8, L11, M30, and M31) were all determined to be IgG2a.

3)-6 Preparation of monoclonal antibody

The monoclonal antibody was purified from the ascites of a mouse implanted with a hybridoma or a hybridoma culture supernatant (hereinafter, referred to as a “starting material for antibody purification”).

[0164]

The mouse ascites was prepared as follows. First,

BALB/cAJcl-nu/nu (CLEA Japan, Inc.) mice at 7 to 8 weeks of age were treated with pristane (manufactured by Sigma Co., Ltd.), and after about 3 weeks, a hybridoma washed with physiological saline was implanted within the abdominal cavity at 1 x 10^7 cells per mouse. After 1 to 2 weeks, the ascites accumulated in the abdominal cavity was collected and sterilized through a 0.22 μm filter, and the resulting material was used as a starting material for antibody purification.

[0165]

The hybridoma culture supernatant was prepared using CELLine (manufactured by BD Biosciences, Inc.). The culturing was performed according to the manufacturer's protocol except that ClonaCell-HY Growth Medium E (manufactured by StemCell Technologies, Inc., #03805) was used as the medium. The collected culture supernatant was filtered through a 0.45 μm filter, and the resulting material was used as a starting material for antibody purification.

[0166]

The antibody was purified by an affinity column obtained by immobilizing Recombinant Protein A rPA50 (manufactured by RepliGen Corporation) on Formyl-Cellulofine (manufactured by Seikagaku Corporation) (hereinafter abbreviated as "Formyl-Cellulofine Protein A") or Hitrap MabSelect SuRe (manufactured by GE Healthcare Bio-Sciences Corporation). In the case of the Formyl-Cellulofine Protein A, the starting

material for antibody purification was diluted to 3-fold with a binding buffer (3 M NaCl, 1.5 M glycine, pH 8.9), and the resulting solution was added to a column, then, the column was washed with the binding buffer, followed by elution with 0.1 M citric acid (pH 4.0). On the other hand, in the case of the Hitrap MabSelect SuRe (GE Healthcare Corporation), the starting material for antibody purification was added to a column, and the column was washed with PBS, followed by elution with 2 M Arginine-HCl (pH 4.0).

After the eluted antibody solution was neutralized, the buffer was exchanged with PBS.

[0167]

The concentration of the antibody was obtained by eluting the antibody bound to POROS G 20 μm Column PEEK, 4.6 mm × 100 mm, 1.7 ml (Applied Biosystems, Inc.) and measuring the absorbance (O.D. 280 nm) of the eluate. Specifically, an antibody sample diluted with PBS was added to POROS G 20 μm equilibrated with an equilibrating buffer (30.6 mM sodium dihydrogen phosphate/12 aq., 19.5 mM monopotassium phosphate, 0.15 M NaCl, pH 7.0). Then, the column was washed with the equilibrating buffer, and the antibody bound to the column was then eluted with an eluent (0.1% (v/v) HCl, 0.15 M NaCl). The peak area of the absorbance (O.D. 280 nm) of the eluate was measured, and the concentration was calculated according to the following equation:

[0168]

Concentration of antibody sample (mg/ml) = (Peak area of antibody sample) / (Peak area of reference standard (human IgG1)) × Concentration of reference standard (mg/ml) × Dilution factor of sample.

Further, the concentration of endotoxin contained in the obtained antibody was measured using Endospecy ES-50M Set (Seikagaku Corporation, #020150) and an endotoxin reference standard CSE-L Set (Seikagaku Corporation, #020055) and was confirmed to be 1 EU/mg or less. The resulting antibody was used in the subsequent experiment.

Example 4. Properties of anti-B7-H3 antibody

4)-1 ADCP activity

1.5 mL of thioglycollate was administrated in the abdominal cavity of a Balb/c-nu/nu mouse (female, at 6 to 10 weeks of age) (Charles River Laboratories Japan, Inc.). 5 Days thereafter, macrophages were collected from the abdominal cavity. The macrophages were added to a 24-well plate at 500 μL/well (1×10^5 cells/well) and cultured overnight at 37°C. The thus prepared macrophages were used as effector cells.

The labeling of NCI-H322 cells to be used as target cells was performed using PKH26 dye labeling kit (Sigma Co., Ltd.) The target cells were detached with TrypLE (Invitrogen Corporation) and washed twice with PBS. The cells were

suspended in Diluent C at 1 x 10^7 cells/ml. PKH26 dye stock (1 mM) was diluted to 8 μM with Diluent C, and immediately thereafter, the diluted dye solution was added thereto in an amount equal to that of the cell suspension. The resulting mixture was left at room temperature for 5 minutes. Then, 1 ml of serum was added thereto, and further, a medium with serum was added thereto, and washing was performed twice. The thus prepared cells were used as the target cells.

[0169]

The antibody obtained in Example 3)-6 was diluted to 20 μg/ml with a culture solution. Subsequently, the target cells obtained in Example 4)-1-1 were dispensed at 2 x 10^6 cells/100 μl/tube and mixed. The resulting mixture was left to stand on ice for 30 minutes. The supernatant was removed, and the cells were washed twice with a culture solution and suspended in 500 μl of a culture solution. The supernatant was removed from the effector cells, and the cells having been treated with the antibody and suspended in the culture solution were added thereto and mixed therewith. Then, the cells were cultured for 3 hours in a CO_2 incubator. Thereafter, the cells were detached with Trypsin-EDTA and collected. To the collected cells, an FITC-labeled anti-mouse CD11b antibody (Becton, Dickinson and Company, Ltd.) was added, and the resulting mixture was left to stand on ice for 30 minutes. The supernatant was removed, and the cells were washed twice with

a culture solution. The collected cells were suspended in 300 μl of a culture solution and analyzed by FACS Calibur (Becton, Dickinson and Company, Ltd.). In the CD11b-positive macrophages, a PKH26-positive fraction was evaluated as phagocytosis-positive cells (n=3).

[0170]

As a result, as shown in Fig. 1, L7, L8, L11, M30, and M31 induced the phagocytosis of the NCI-H322 cells by macrophages to give a percentage of phagocytosis of 48.0 ± 0.9%, 52.3 ± 1.1%, 57.1 ± 2.5%, 61.9 ± 2.1%, and 57.7 ± 3.0%, respectively. Accordingly, it was shown that L7, L8, L11, M30, and M31 antibodies have ADCP activity against NCI-H322 cells.

[0171]

In the same manner, commercially available anti-B7-H3 antibodies were obtained and the ADCP activity thereof was measured. A rat anti-human B7-H3 antibody MIH35 (eBioscience Company), a mouse anti-human B7-H3 antibody 185504 (R&D Systems, Inc.), MIH42 (Serotec Co., Ltd.), and DCN70 (Biolegend Company) were obtained. It was confirmed that these antibodies bind to B7-H3 in the same manner as in Example 3)-3. By using these antibodies, the ADCP activity was measured by the above method.

As a result, as shown in Fig. 2, when being added at 1 μg/ml, MIH35, MIH42, and DCN70 induced the phagocytosis of the NCI-H322 cells by macrophages to give a percentage of phagocytosis of 4.2%, 8.2%, and 10.8%, respectively.

Accordingly, it was revealed that MIH35, MIH42, and DCN70 exhibited almost no ADCP activity.

From these results, it was shown that the M30 clones recognizing B7-H3 obtained by screening have a markedly higher ADCP activity than the commercially available B7-H3 antibodies.

4)-2 ADCC activity

4)-2-1 Preparation of effector cells

The spleen was aseptically excised from a nude mouse CAnN.Cg-Foxn1^{nu}/CrlCrlj (Charles River Laboratories Japan, Inc.). The excised spleen was homogenized with two slide glasses, and subjected to a hemolysis treatment using BD Pharm Lyse (manufactured by BD Biosciences, Ltd. #555899). The thus obtained spleen cells were suspended in phenol red-free RPMI 1640 (manufactured by Invitrogen Corporation) containing 10% Fetal Bovine Serum, Ultra-low IgG (manufactured by Invitrogen Corporation) (hereinafter abbreviated as "ADCC medium"), and the cell suspension was passed through a cell strainer (pore size: 40 μm, manufactured by BD Biosciences, Ltd.). Then, the viable cells were counted by a trypan blue dye exclusion assay. After the spleen cell suspension was centrifuged, the medium was removed, and the cells were resuspended in the ADCC medium at a viable cell density of 1.5 x 10^7 cells/ml and used as effector cells.

4)-2-2 Preparation of target cells

B7-H3-expressing 293 cells (ATCC) and empty vector-transfected 293 cells prepared in the same manner as in Example 3)-3 were treated with trypsin, and the treated cells of each type were washed with 10% FBS-containing RPMI 1640 (Invitrogen Corporation) and then resuspended in 10% FBS-containing RPMI 1640. The cells (4×10^6 cells) of each type were mixed with chromium-51 (5550 kBq) sterilized through a 0.22 μm filter, and labeling was performed for 1 hour under the conditions of 37°C and 5% CO_2. The labeled cells were washed three times with 10% FBS-containing RPMI 1640 (Invitrogen Corporation), and the cells were resuspended at 2×10^5 cells/ml in the ADCC medium and used as target cells.

4)-2-3 ^{51}Cr release assay

The target cells at a cell density of 2×10^5 cells/ml were dispensed at 50 μl/well in a 96-well U-shaped bottom microplate. 50 μl of M30 or an isotype control antibody (mIgG2a) (eBioscience Company) was added thereto, diluted with the ADCC medium so that the final concentration of the antibody after adding the effector cells was 2.5 μg/ml. Then, the plate was left to stand at 4°C for 1 hour. Thereafter, 100 μl of the effector cells at a cell density of 1.5×10^7 cells/ml were added thereto, and the cells were cultured overnight under the

conditions of 37°C and 5% CO_2. On the next day, the supernatant was collected in a LumaPlate (manufactured by PerkinElmer, Inc.), and gamma radiation emitted therefrom was measured using a gamma counter. The percentage of cell lysis caused by the ADCC activity was calculated according to the following equation.

[0172]

Percentage of cell lysis (%) = (A–B) / (C–B) x 100

A: Radiation count from the sample well

B: Average spontaneous radiation emission count (from wells to which the antibody and the effector cells were not added) (n=3). The same procedure as that for the sample well was performed except that the ADCC medium was added in an amount of 50 μl at the time of adding the antibody and in an amount of 100 μl at the time of adding the effector cells.

[0173]

C: Average maximum radiation emission count (from wells in which the target cells were dissolved with a surfactant) (n=3). The same procedure as that for the sample well was performed except that 50 μl of the ADCC medium was added at the time of adding the antibody and 100 μl of the ADCC medium containing 2% (v/v) Triton X–100 was added at the time of adding the effector cells.

[0174]

The data shown are an average of triplicate measurements,

and the error bars represent standard deviations. The P value was calculated using Student's t-test. The measurement results are shown in Fig. 3.

As a result, M30 exhibited cell lysis activity with a percentage of cell lysis of 31.6 ± 3.3% against the B7-H3-expressing 293 cells, and therefore, it was shown that the M30 antibody has ADCC activity against the B7-H3-expressing 293 cells.

4)-3 CDC activity

An experiment was performed in the same manner as in Example 2)-3. As the cells for use in the evaluation, NCI-H322 cells were used. Each of the anti-B7-H3 antibodies (L7, L8, L11, M30, and M31) obtained in Example 3)-6 and an isotype control antibody (mIgG2a) diluted with 10% FBS-containing RPMI 1640 (containing antibiotics: penicillin and streptomycin) was added so that the final concentration of the antibody after adding complement was 25 μg/ml, and the resulting mixture was left to stand at 4°C for 1 hour. Thereto was added rabbit complement (manufactured by Cedarlane Laboratories, #CL3051) diluted to 30% with RPMI 1640 so that the final concentration of the complement was 5%, and the resulting mixture was incubated for 1 hour under the conditions of 37°C and 5% CO_2. Then, the mixture was left to stand at room temperature for 30 minutes. In order to measure the cell

viability, CellTiter-Glo Luminescent Cell Viability Assay (manufactured by Promega Corporation) was added thereto in an amount equal to that of the culture solution, and the resulting mixture was stirred at room temperature for 10 minutes. Thereafter, the amount of luminescence was measured using a plate reader. The cell viability was calculated according to the following equation.

[0175]

Cell viability (%) = (a-b) / (c-b) x 100

a: Amount of luminescence from the sample well

b: Average amount of luminescence of background (from wells to which the cells and the antibody were not added) (n=3). The same procedure as that for the sample well was performed except that an equal amount of 10% FBS-containing RPMI 1640 (containing antibiotics: penicillin and streptomycin) was added in place of the cell suspension at the time of cell seeding and 10% FBS-containing RPMI 1640 (containing antibiotics: penicillin and streptomycin) was added in an amount equal to that of the antibody dilution solution at the time of adding the antibody.

[0176]

c: Average amount of luminescence from wells to which the antibody was not added (n=3). The same procedure as that for the sample well was performed except that 10% FBS-containing RPMI 1640 (containing antibiotics: penicillin

and streptomycin) was added in an amount equal to that of the antibody dilution solution at the time of adding the antibody.

[0177]

The measurement results are shown in Fig. 4. The data shown are an average of triplicate measurements, and the error bars represent standard deviations. As a result, the control antibody, L7, L8, L11, M30, and M31 induced a decrease in cell viability of the NCI-H322 cells to 101.5 ± 3.3%, 6.3 ± 4.2%, 13.6 ± 9.1%, 7.2 ± 1.4%, 7.5 ± 1.8%, and 12.8 ± 2.0%, respectively, in the presence of complement. Therefore, it was shown that the L7, L8, L11, M30, and M31 antibodies have CDC activity against the NCI-H322 cells.

4)-4 Determination of binding domain

It was examined as to which domain of B7-H3 M30 binds by a flow cytometric method in the same manner as in Example 3)-3. The NIH-3T3 cells transfected with each of the expression vectors for B7-H3 partial proteins prepared in Example 1)-1-3 were used.

As a result, as shown in Fig. 5, it was confirmed that M30 binds to B7-H3 IgC1, B7-H3 IgC2, B7-H3 IgC1-V2-C2, and B7-H3 IgV2-C2. M30 did not bind to B7-H3 IgV1 and B7-H3 IgV2.

From these results, it was shown that M30 binds to the C1 domain (the amino acid sequence represented by amino acid numbers 140 to 244 in SEQ ID NO: 6) and the C2 domain (the amino

acid sequence represented by amino acid numbers 358 to 456 in SEQ ID NO: 6) of B7-H3. In the same manner, it was also shown that L8, L11, and M31 bind to the C1 domain and the C2 domain, and L7 binds to the V1 domain (the amino acid sequence represented by amino acid numbers 27 to 139 in SEQ ID NO: 6) and the V2 domain (the amino acid sequence represented by amino acid numbers 245 to 357 in SEQ ID NO: 6).

[0178]

Accordingly, it was shown that M30 recognizes an epitope in the IgC1 domain and/or the IgC2 domain, each of which is a domain in the B7-H3 extracellular domain, and binds to the IgC1 domain or the IgC2 domain or both.

4)-5 Antigen specificity

The antigen specificity of M30 was examined by a flow cytometric method in the same manner as in Example 3)-3.

293T cells transfected with each of the expression vectors for the CD80, CD86, B7-RP-1, B7-H1, B7-DC, and B7-H4 proteins, which are B7 family proteins, prepared in Example 1)-1-4 were used.

As a result, it was shown that M30 does not bind to CD80, CD86, B7-RP-1, B7-H1, B7-DC, and B7-H4, which are B7 family molecules.

Example 5. In vivo antitumor effect

5)-1 In vivo antitumor effect of anti-B7-H3 antibody

NCI-H322 cells were detached from a culture flask by a trypsin treatment, and then suspended in 10% FBS-containing RPMI 1640 (Invitrogen Corporation), followed by centrifugation, and the supernatant was removed. The cells were washed twice with the same medium, and then suspended in physiological saline (manufactured by Otsuka Pharmaceutical Co., Ltd.). Then, the cells were implanted subcutaneously in the axillary region of each of a group of BALB/cAJcl-nu/nu (CLEA Japan, Inc.) mice at 6 weeks of age at a dose of 1×10^7 cells/mouse. The day of implantation was taken as day 0, and on days 10, 17, 24, 31, and 38, each of the L7, L8, L11, M30, and M31 antibodies was intraperitoneally administered at a dose of 500 μg/mouse (about 25 mg/kg). To the control, PBS was intraperitoneally administered in a volume (500 μl) equal to that of the antibody. The tumor volume was measured on days 10, 17, 24, 31, 38, and 45, and the antitumor effect of the administration of the antibody was examined.

As a result, in the M30 and M31 administration groups, the tumor growth was significantly suppressed as compared with the PBS administration group. (The P values for M30 and M31 compared with the PBS administration group in terms of the tumor volume on day 45 were $P<0.05$ and $P<0.01$, respectively. The P values were calculated using Student's t-test.). Further, the tumor growth inhibition ratio (= 100 - (average tumor volume

in antibody administration group) / (average tumor volume in PBS administration group) x 100) on day 45 in the case of L7, L8, L11, M30, and M31 was -16.1%, 0.2%, 25.5%, 47.2%, and 58.2%, respectively. Accordingly, the M30 and M31 antibodies were observed to have a very strong antitumor effect in vivo (Fig. 6).

[0179]

From the above results, it was revealed that the M30 and M31 antibodies are antibodies which recognize a B7-H3 antigen and exhibit an antitumor effect.

5)-2 In vivo antitumor effect under conditions of depletion of macrophages

In order to deplete macrophages in vivo, clodronate-encapsulated liposomes were produced. It has been reported that by administering clodronate-encapsulated liposomes in vivo, macrophages in vivo are depleted (Journal of immunological methods 1994, vol. 174, pp. 83-93). According to the method in this report, clodronate-encapsulated liposomes were produced and used in the following experiment.

[0180]

NCI-H322 cells were detached from a culture flask by a trypsin treatment, and then suspended in 10% FBS-containing RPMI 1640 (Invitrogen Corporation), followed by

centrifugation and the supernatant was removed. The cells were washed twice with the same medium, and then suspended in physiological saline (PBS, manufactured by Otsuka Pharmaceutical Co., Ltd.). Then, the cells were implanted subcutaneously in the axillary region of each BALB/cAJcl-nu/nu (CLEA Japan, Inc.) mouse at 6 weeks of age at a dose of 1 x 10^7 cells/mouse. The day of implantation was taken as day -14, and grouping was performed on day 0.

In a group in which the macrophages in vivo in the mice were to be depleted, the clodronate-encapsulated liposomes were intravenously injected at a dose of 0.2 mL/mouse on days 0, 4, 7, 11, 14, 18, 21, 25, 28, and 32. Further, in the negative control group, PBS was intravenously injected at a dose of 0.2 mL/mouse on the same days (on days 0, 4, 7, 11, 14, 18, 21, 25, 28, and 32).

Subsequently, the M30 antibody was intraperitoneally administered to both groups at a dose of 500 μg/mouse (about 25 mg/kg) on days 1, 8, 15, 22, and 29. Further, as the negative control, PBS was intraperitoneally administered to both groups in a volume (500 μl) equal to that of the M30 antibody on the same days (on days 1, 8, 15, 22, and 29).

The tumor volume was measured on days 0, 8, 15, 22, 29, and 36, and the antitumor effect of the administration of the antibody was examined (n=8).

The results are shown in Tables 1 and 2, and Fig. 7.

[0181]

[Table 1]

Tumor volume	On day 0		On day 8		On day 15	
	Average (mm^3)	Standard deviation	Average (mm^3)	Standard deviation	Average (mm^3)	Standard deviation
PBS + PBS administration group	104.375	6.491581086	149	10.60828517	227.5	18.20027472
Clod lip + PBS administration group	114.625	4.862162585	159.375	7.676349346	318.625	26.37567704
PBS + M30 administration group	103.5	7.221001118	123.625	14.89958952	145	19.58497967
Clod lip + M30 administration group	104.625	5.47049717	143.375	10.46753058	247.75	24.44947414

Tumor volume	On day 22		On day 29		On day 36	
	Average (mm^3)	Standard deviation	Average (mm^3)	Standard deviation	Average (mm^3)	Standard deviation
PBS + PBS administration group	394.75	25.77772433	601.25	43.17065389	827	50.82638516
Clod lip + PBS administration group	443.625	23.52653327	619.75	40.9550058	1002.75	78.18493415
PBS + M30 administration group	186.25	25.920035	301.75	47.13610612	415.25	79.84175197
Clod lip + M30 administration group	384.25	40.10644319	641.375	80.12176838	837.25	121.349223

[0182]

In the group of PBS intravenous administration + M30 antibody intraperitoneal administration (PBS + M30 administration group), the tumor growth was significantly suppressed as compared with the group of PBS intravenous administration + PBS intraperitoneal administration (PBS + PBS administration group) serving as the negative control. To be more specific, the P value for the PBS + M30 administration group compared with the PBS + PBS administration group in terms of the tumor volume on day 36 was $P<0.05$ (The P value was

calculated using Student's t-test.). Further, the tumor growth inhibition ratio (= 100 - (average tumor volume in PBS + M30 administration group) / (average tumor volume in PBS + PBS administration group) x 100) on day 36 was 49.8% (Table 2).

On the other hand, in the group of clodronate-encapsulated liposome intravenous administration + PBS intraperitoneal administration (Clod lip + PBS administration group) and the group of clodronate-encapsulated liposome intravenous administration + M30 antibody intraperitoneal administration (Clod lip + M30 administration group), the suppression of tumor growth was not observed. To be more specific, the P values for the Clod lip + PBS administration group and the Clod lip + M30 administration group compared with the PBS + PBS administration group in terms of the tumor volume on day 36 were P=0.52 and P=1, respectively. (The P values were calculated using Student's t-test). Further, the tumor growth inhibition ratios (= 100 - (average tumor volume in Clod lip + PBS administration group or Clod lip + M30 administration group) / (average tumor volume in PBS + PBS administration group) x 100) on day 36 were -21.2% and -1.4%, respectively (Table 2).

[0183]

[Table 2]

Tumor growth inhibition ratio (%)	On day 8	On day 15	On day 22	On day 29	On day 36
Clod lip + PBS administration group	-6.6	-39.4	-12.6	-3.5	-21.2
PBS + M30 administration group	17.5	36.4	52.8	49.7	49.8
Clod lip + M30 administration group	3.2	-8.6	2.6	-6.6	-1.4

[0184]

From the above results, it was shown that the antitumor effect of the M30 antibody was suppressed by administering clodronate-encapsulated liposomes, and therefore, it was revealed that the antitumor effect of the M30 antibody is mainly an effect mediated by macrophages.

Example 6. Cloning of mouse antibody M30 cDNA and determination of sequence

6)-1 Determination of N-terminal amino acid sequences of heavy and light chains of mouse antibody M30

In order to determine the N-terminal amino acid sequences of the heavy and light chains of the mouse antibody M30, the mouse antibody M30 purified in Example 3)-6 was separated by SDS-PAGE. The protein in the gel was transferred from the gel after separation to a PVDF membrane (pore size: 0.45 μm, manufactured by Invitrogen Corporation). The membrane was washed with a washing buffer (25 mM NaCl, 10 mM sodium borate buffer pH 8.0), and thereafter stained by being immersed in

a dye solution (50% methanol, 20% acetic acid, 0.05% Coomassie brilliant blue) for 5 minutes, followed by destaining with 90% methanol. The portions of the band corresponding to the heavy chain (the band with smaller mobility) and the band corresponding to the light chain (the band with larger mobility) visualized on the PVDF membrane were excised.

The portion of the band corresponding to the light chain was incubated at 37°C for 30 minutes in a small amount of a 0.5% polyvinylpyrrolidone/100 mM acetic acid solution, followed by washing well with water. Subsequently, modified N-terminal residue was removed using Pfu Pyroglutamate Aminopeptidase Kit (TaKaRa Bio, Inc.), followed by washing with water and air drying. Then, an attempt was made to identify their respective N-terminal amino acid sequences by an automatic Edman method (see Edman et al. (1967) Eur. J. Biochem. 1, 80) using Procise (registered trademark) cLC Protein Sequencer Model 492cLC (Applied Biosystems, Inc.).

As a result, the N-terminal amino acid sequence of the band corresponding to the heavy chain of the mouse antibody M30 was determined to be EVQLQQSGPE (SEQ ID NO: 44 in the Sequence Listing), and the N-terminal amino acid sequence of the band corresponding to the light chain thereof was determined to be IVLSQSPTILSASP (SEQ ID NO: 45 in the Sequence Listing).

6)-2 Preparation of mRNA from mouse antibody M30-producing hybridoma

In order to clone cDNAs encoding each of the heavy chain and the light chain of the mouse antibody M30, mRNA was prepared from the mouse antibody M30-producing hybridoma using Quick Prep mRNA Purification Kit (GE Healthcare Corporation).

6)-3 Cloning of mouse antibody M30 cDNA and determination of sequence

With reference to the findings that the isotypes of the heavy and light chains of the mouse antibody M30 are γ2a and κ found in Example 3)-5, and the N-terminal amino acid sequences of the heavy and light chains determined in Example 1-1), and the database of the amino acid sequences of antibodies (see Kabat, E. A. et al., (1991) in Sequences of Proteins of Immunological Interest Vol. I and II, U.S. Department of Health and Human Services), several oligonucleotide primers hybridizing to each of the 5'-terminal region of an antibody gene coding region and the 3'-terminal region thereof comprising a stop codon were synthesized, and a cDNA encoding the heavy chain and a cDNA encoding the light chain were amplified using the mRNA prepared in Example 6-2) and TaKaRa One Step RNA PCR Kit (AMV) (TaKaRa Bio, Inc.). As a result, the cDNA encoding the heavy chain of the antibody and the cDNA encoding the light chain of the antibody could be amplified

by the following primer sets.

Primer set for the heavy chain

Primer 16

5′-aagaattcatggaatggagttggata-3′ (SEQ ID NO: 46 in the Sequence Listing)

Primer 17

5′-aagatatctcatttacccggagtccgggagaa-3′ (SEQ ID NO: 47 in the Sequence Listing)

Primer set for the light chain

Primer 18

5′-aagaattcatggattttctggtgcag-3′ (SEQ ID NO: 48 in the Sequence Listing)

Primer 19

5′-aagatatcttaacactcattcctgttgaagct-3′ (SEQ ID NO: 49 in the Sequence Listing)

Each of the cDNA encoding the heavy chain and the cDNA encoding the light chain amplified by PCR was cloned using pEF6/V5-His TOPO TA Expression Kit (Invitrogen Corporation), and each of the nucleotide sequences of the heavy chain and the light chain cloned was determined using a gene sequence analyzer (“ABI PRISM 3700 DNA Analyzer; Applied Biosystems” or “Applied Biosystems 3730xl Analyzer; Applied Biosystems”). In the sequencing reaction, GeneAmp 9700 (Applied Biosystems, Inc.) was used.

The determined nucleotide sequence of the cDNA encoding

the heavy chain of the mouse antibody M30 is represented by SEQ ID NO: 50 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 51. Further, the sequences of SEQ ID NOS: 50 and 51 are shown in Fig. 21.

The determined nucleotide sequence of the cDNA encoding the light chain of the mouse antibody M30 is represented by SEQ ID NO: 52 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 53 in the Sequence Listing. The sequences of SEQ ID NOS: 52 and 53 are shown in Fig. 22.

Further, the amino acid sequences of the heavy chain and the light chain were analyzed by comparison using KabatMan (see PROTEINS: Structure, Function and Genetics, 25 (1996), 130-133), which is the database of the amino acid sequences of antibodies. As a result, it was found that in the heavy chain of the mouse antibody M30, the amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 51 in the Sequence Listing is the variable region. It was also found that in the light chain of the mouse antibody M30, the amino acid sequence represented by amino acid numbers 23 to 130 in SEQ ID NO: 53 in the Sequence Listing is the variable region.

Example 7. Production of chimeric antibody M30 (cM30 antibody)

7)-1

Construction of chimeric and humanized light chain expression vector pEF6KCL

By performing PCR using a plasmid pEF6/V5-HisB (Invitrogen Corporation) as a template and also using the following primers, a DNA fragment from immediately downstream of BGHpA (Sequence Position: 2174) to SmaI (Sequence Position: 2958) (a DNA fragment comprising f1 origin of replication and SV40 promoter and origin, hereinafter referred to as “fragment A”) was obtained.

Primer 20

5′-ccacgcgccctgtagcggcgcattaagc-3′ (SEQ ID NO: 54 in the Sequence Listing)

Primer 21

5′-aaacccgggagcttttttgcaaaagcctagg-3′ (SEQ ID NO: 55 in the Sequence Listing)

The obtained fragment A and a DNA fragment (SEQ ID NO: 56, hereinafter referred to as “fragment B”, the sequence of SEQ ID NO: 56 is also shown in Fig. 23) comprising a DNA sequence encoding a human κ chain secretory signal, a human κ chain constant region, and a human poly-A additional signal were ligated to each other by overlap extension PCR. The thus obtained DNA fragment in which the fragment A and the fragment B were ligated to each other was digested with the restriction enzymes KpnI and SmaI, which was ligated to a plasmid

pEF6/V5-HisB (Invitrogen Corporation) which was digested with the restriction enzymes KpnI and SmaI, whereby a chimeric and humanized light chain expression vector pEF6KCL having a signal sequence, a cloning site, a human κ chain constant region, and a human poly-A additional signal sequence downstream of the EF1 promoter was constructed.

7)-2 Construction of pEF1KCL

A DNA fragment obtained by cleaving the pEF6KCL obtained by the above-described method with the restriction enzymes KpnI and SmaI was ligated to pEF1/myc-HisB (Invitrogen Corporation) which was digested with KpnI and SmaI, whereby a plasmid pEF1KCL was constructed.

7)-3 Construction of chimeric and humanized heavy chain expression vector pEF1FCCU

A DNA fragment (SEQ ID NO: 57, the sequence of SEQ ID NO: 57 is also shown in Fig. 24) comprising a DNA sequence encoding amino acids of a signal sequence and a constant region of human IgG1 was digested with the restriction enzymes NheI and PmeI and was ligated to the plasmid pEF1KCL which was digested with NheI and PmeI, whereby a chimeric and humanized heavy chain expression vector pEF1FCCU having a signal sequence, a cloning site, a human heavy chain constant region, and a human poly-A additional signal sequence downstream of the EF1

promoter was constructed.

7)-4 Construction of M30 chimera-type light chain expression vector

By using the cDNA encoding the light chain of the mouse antibody M30 as a template and also using KOD-Plus- (TOYOBO, Co., Ltd.) and the following primer set, a region comprising the cDNA encoding the light chain variable region was amplified. A DNA fragment obtained by cleaving the amplified product with the restriction enzymes NdeI and BsiWI was inserted into the universal chimeric and humanized antibody light chain expression vector (pEF6KCL) at the site cleaved with the restriction enzymes NdeI and BsiWI, whereby an M30 chimera-type light chain expression vector was constructed. The thus obtained expression vector was named “pEF6KCL/M30L”. The nucleotide sequence of the M30 chimera-type light chain is represented by SEQ ID NO: 58 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 59. The sequences of SEQ ID NOS: 58 and 59 are shown in Fig. 25. Incidentally, a threonine residue at position 128 in the amino acid sequence of the cM30 antibody light chain represented by SEQ ID NO: 59 in the Sequence Listing is located in the carboxyl terminus of the light chain variable region and corresponds to an alanine residue at position 130 in the amino acid sequence of the M30 antibody light chain represented by SEQ ID NO: 53

in the Sequence Listing, however, in the amino acid sequence represented by SEQ ID NO: 59, the residue has already been substituted with a threonine residue derived from a human antibody light chain.

Primer set for the light chain

Primer 22

5'-aaacatatggccaaattgttctctcccagtctccaacaatcc-3' (SEQ ID NO: 60 in the Sequence Listing)

Primer 23

5'-aaacgtacgtttcagctccagcttggtcccagtaccg-3' (SEQ ID NO: 61 in the Sequence Listing)

7)-5 Construction of M30 chimera-type heavy chain expression vector

By using the cDNA encoding the heavy chain of the mouse antibody M30 as a template, a DNA fragment obtained by performing PCR using KOD-Plus- (TOYOBO, Co., Ltd.) and the following primer set A was ligated to a DNA fragment obtained by performing PCR using the following primer set B through overlap extension PCR using the following primer set C, whereby the BlpI in the variable region was removed and also a region comprising the cDNA encoding the heavy chain variable region was amplified. A DNA fragment obtained by cleaving the amplified product with the restriction enzyme BlpI was inserted into the universal chimeric and humanized antibody heavy chain

expression vector (pEF1FCCU) at the site cleaved with the restriction enzyme BlpI, whereby an M30 chimera-type heavy chain expression vector was constructed. The thus obtained expression vector was named “pEF1FCCU/M30H”.

The nucleotide sequence of the M30 chimera-type heavy chain is represented by SEQ ID NO: 62 in the Sequence Listing, and the amino acid sequence thereof is represented by SEQ ID NO: 63. Further, the sequences of SEQ ID NOS: 62 and 63 are shown in Fig. 26.

Primer set A

Primer 24

5’-aaagctgagcgaggtccagctgcagcagtctggacctgag-3’ (SEQ ID NO: 64 in the Sequence Listing)

Primer 25

5’-gaggtcaggctgctgagttccatgtaggctgtgctg-3’ (SEQ ID NO: 65 in the Sequence Listing)

Primer set B

Primer 26

5’-cagcacagcctacatggaactcagcagcctgacctc-3’ (SEQ ID NO: 66 in the Sequence Listing)

Primer 27

5’-aaagctgagctgactgtgagagtggtgccttggccccag-3’ (SEQ ID NO: 67 in the Sequence Listing)

Primer set C

Primer 28

5′-aaagctgagcgaggtccagctgcagcagtctggacctgag-3′ (SEQ ID NO: 68 in the Sequence Listing)

Primer 29

5′-aaagctgagctgactgtgagagtggtgccttggccccag-3′ (SEQ ID NO: 69 in the Sequence Listing)

7)-6 Preparation of chimeric antibody M30

7)-6-1 Production of chimeric antibody M30

1.2×10^9 cells of FreeStyle 293F cells (Invitrogen Corporation) in the logarithmic growth phase were seeded into 1.2 L of fresh FreeStyle 293 Expression Medium (Invitrogen Corporation) and cultured for 1 hour by shaking at 90 rpm at 37°C in an 8% CO_2 incubator. 3.6 mg of polyethyleneimine (Polyscience #24765) was dissolved in 20 ml of Opti-Pro SFM medium (Invitrogen Corporation). Subsequently, pEF1FCCU/M30H (0.4 mg) and pEF6KCL/M30L (0.8 mg) prepared with PureLink HiPure Plasmid Kit (Invitrogen Corporation) were suspended in 20 ml of Opti-Pro SFM medium. Then, 20 ml of the obtained expression vectors/Opti-Pro SFM mixed liquid was added to 20 ml of the obtained polyethyleneimine/Opti-Pro SFM mixed liquid, and the resulting mixture was gently stirred and then left for 5 minutes. Thereafter, the mixture was added to the FreeStyle 293F cells, and shaking culture at 90 rpm was performed for 7 days at 37°C in an 8% CO_2 incubator. The resulting culture supernatant was filtered through a

disposable capsule filter (Advantec #CCS-045-E1H).

A chimeric antibody M30 obtained by a combination of pEF1FCCU/M30H and pEF6KCL/M30L was named “cM30” or “cM30 antibody”.

7)-6-2 Purification of cM30

The culture supernatant obtained in Example 7)-6-1 was purified by a two-step process including rProtein A affinity chromatography (at 4 to 6°C) (GE Healthcare Japan Corporation) and ceramic hydroxyapatite (at room temperature). A buffer exchange step after the purification by rProtein A affinity chromatography and after the purification by ceramic hydroxyapatite was performed at room temperature. First, 1100 to 1200 ml of the culture supernatant was applied to MabSelect SuRe (manufactured by GE Healthcare Bio-Sciences Corporation, two HiTrap columns (volume: 1 ml) connected in series) equilibrated with PBS. After all culture solution was poured into the column, the column was washed with 15 to 30 ml of PBS. Subsequently, elution was performed with a 2 M arginine hydrochloride solution (pH 4.0), and a fraction containing the antibody was collected. The fraction was applied to a desalting column (manufactured by GE Healthcare Bio-Sciences Corporation, two HiTrap desalting columns (volume: 5 ml) connected in series), whereby the buffer was exchanged with a buffer containing 5 mM sodium phosphate, 50 mM MES, and 20

mM NaCl at pH 6.5.

Further, the antibody solution subjected to buffer exchange was applied to a ceramic hydroxyapatite column (Japan Bio-Rad Laboratories, Inc., Bio-Scale CHT2-1 hydroxyapatite column (volume: 2 ml)) equilibrated with a buffer containing 5 mM NaPi, 50 mM MES, and 20 mM NaCl at pH 6.5. Then, linear concentration gradient elution with sodium chloride was performed, and a fraction containing the antibody was collected. The fraction was applied to a desalting column (manufactured by GE Healthcare Bio-Sciences Corporation, two HiTrap Desalting columns (volume: 5 ml) connected in series), whereby the liquid was exchanged with CBS (containing 10 mM citrate buffer and 140 mM sodium chloride, pH 6.0).

Finally, the resulting solution was concentrated using Centrifugal UF Filter Device VIVASPIN 20 (fractional molecular weight: 30 K, Sartorius Co., Ltd., at 4°C), and the concentration of IgG was adjusted to 1.0 mg/ml or more, and the thus obtained solution was used as a purified sample.

Example 8. Activity of cM30 antibody

8)-1 Binding activity of cM30 antibody to B7-H3

The affinity between the M30 antibody or the cM30 antibody and the B7-H3 antigen was measured by a surface plasmon resonance (SPR) device (GE Healthcare Corporation). According to common procedures, an anti-mouse IgG or an

anti-human IgG antibody was immobilized on a sensor chip, and then, the M30 antibody sample or the cM30 antibody was bound thereto. Thereafter, an extracellular domain polypeptide of a recombinant B7-H3 variant 2 antigen (manufactured by R&D Systems, Inc., #2318-B3-050/CF) was added thereto at different concentrations, and the amount of the antigen bound to the antibody in a running buffer (phosphate buffer, 0.05% SP20) was measured over time. The measured amount was analyzed with dedicated software (BIAevaluation Version 4.1, GE Healthcare Corporation) and a dissociation constant was calculated.

As a result, the M30 antibody and the cM30 antibody were found to have bound to the recombinant B7-H3 antigen with a dissociation constant of 5.89 nM and 3.43 nM, respectively. From these results, it was confirmed that the M30 antibody and the cM30 antibody bind to the B7-H3 antigen and their binding affinities were substantially equal.

8)-2 ADCP activity of cM30 antibody

Peripheral blood mononuclear cells (PBMCs) of a healthy subject were isolated according to common procedures and suspended in 10% FBS-containing RPMI 1640 (Invitrogen Corporation) and then seeded in a flask. The cells were cultured overnight in a CO_2 incubator. The culture supernatant was removed, and to the cells attached to the flask, 10% FBS-containing RPMI 1640 supplemented with M-CSF and GM-CSF (PeproTech, Inc.) was added, and the cells

were cultured for 2 weeks. The cells were detached with TrypLE and collected. Then, the cells were added to a 24-well plate at 500 μl/well (1 x 10^5 cells/well) and cultured overnight at 37°C. The thus prepared cells were used as effector cells.

The labeling of NCI-H322 cells to be used as target cells was performed using PKH26 dye labeling kit (Sigma Co., Ltd.). The target cells were detached with TrypLE and washed twice with PBS. The cells were suspended in Diluent C at 1 x 10^7 cells/ml. PKH26 dye stock (1 mM) was diluted to 8 μM with Diluent C, and immediately thereafter, the diluted dye solution was added thereto in an amount equal to that of the cell suspension. The resulting mixture was left at room temperature for 5 minutes. Then, 1 ml of serum was added thereto, and further, a medium with serum was added thereto, and washing was performed twice.

[0185]

Each of the M30 antibody and the cM30 antibody was diluted to 20 μg/ml with a culture solution. Subsequently, the target cells were dispensed at 2 x 10^6 cells/100 μl/tube and mixed. The resulting mixture was left to stand on ice for 30 minutes. The supernatant was removed, and the cells were washed twice with a culture solution and suspended in 500 μl of a culture solution. The supernatant was removed from the effector cells, and the cells having been treated with the antibody and suspended in the culture solution were added thereto and mixed

therewith. Then, the cells were cultured for 3 hours in a CO_2 incubator. Thereafter, the cells were detached with Trypsin-EDTA and collected. To the collected cells, an FITC-labeled anti-mouse CD11b antibody (Becton, Dickinson and Company, Ltd.) was added, and the resulting mixture was left to stand on ice for 30 minutes. The supernatant was removed, and the cells were washed twice with a culture solution. The collected cells were suspended in 300 μl of a culture medium and analyzed by FACS Calibur (Becton, Dickinson and Company, Ltd.). In the CD11b-positive macrophages, a PKH26-positive fraction was evaluated as phagocytosis-positive cells.

[0186]

As a result, as shown in Fig. 8, when the M30 antibody and the cM30 antibody were added at 10 μg/ml, the phagocytosis of the NCI-H322 cells by macrophages was induced to 33 ± 1% and 35 ± 2%, respectively. Accordingly, it was shown that the cM30 antibody has an ADCP activity against the NCI-H322 cells in the same manner as the M30 antibody. A similar experimental result was obtained also for an ADCP activity against MDA-MB-231 cells (ATCC).

8)-3 In vivo antitumor effect of cM30 antibody

MDA-MB-231 cells were detached from a culture flask by a trypsin treatment, and then suspended in 10% FBS-containing RPMI 1640 medium (Invitrogen Corporation), followed by

centrifugation and the supernatant was removed. The cells were washed twice with the same medium, and then suspended in BD Matrigel Basement Membrane Matrix (manufactured by BD Biosciences, Inc.). Then, the cells were implanted subcutaneously in the axillary region of each mouse (CB17/Icr-Prkdc[scid]/CrlCrlj, Charles River Laboratories Japan, Inc.) at 6 weeks of age at a dose of 5×10^6 cells/mouse. The day of implantation was taken as day 0, and on days 14, 21, 28, 35, and 42, the M30 antibody or the cM30 antibody was intraperitoneally administered at a dose of 500 μg/mouse (about 25 mg/kg). The tumor volume was measured on days 14, 18, 21, 25, 28, 32, 35, 39, 42, 46, 49, and 52, and the antitumor effect of the administration of the antibody was examined.

As a result, in the M30 and cM30 antibody administration groups, the tumor growth was significantly suppressed as compared with the untreated group in which the antibody was not administered. The P values for the M30 antibody and the cM30 antibody compared with the untreated group in terms of the tumor weight on day 52 were both $P<0.001$. The P values were calculated using Dunnett's multiple comparison test.

Further, the tumor growth inhibition ratio (= 100 - (average tumor volume in antibody administration group) / (average tumor volume in untreated group) x 100) on day 52 was 71.3% in the case of the M30 antibody and 71.7% in the case of the cM30 antibody. Accordingly, the cM30 antibody was

observed to have a very strong antitumor effect in vivo in the same manner as the M30 antibody (Fig. 9).

Example 9. Designing of humanized antibody of mouse anti-human B7-H3 antibody #M30

9)-1 Designing of humanized M30 antibody

9)-1-1 Molecular modeling of M30 variable regions

The molecular modeling of the M30 variable regions was performed according to a method generally known as homology modeling (Methods in Enzymology, 203, 121-153, (1991)). The primary sequences (three-dimensional structures derived from the X-ray crystal structures are available) of the variable regions of human immunoglobulin registered in Protein Data Bank (Nuc. Acid Res. 35, D301-D303 (2007)) were compared with the M30 variable regions determined in Example 6-3).

As a result, 3BKY was selected as a sequence having the highest sequence homology with the M30 light chain variable region among the antibodies which similarly have a deletion in the framework. Further, 3DGG was selected as a sequence having the highest sequence homology with the M30 heavy chain variable region.

The three-dimensional structure of a framework region was prepared based on a “framework model” by combining the coordinates of 3BKY corresponding to the M30 light chain with the coordinates of 3DGG corresponding to the M30 heavy chain.

As for the M30 CDRs, as the coordinates defining the conformations most similar to those of CDRH1 (SEQ ID NO: 92), CDRH2 (SEQ ID NO: 93), CDRH3 (SEQ ID NO: 94), CDRL1 (SEQ ID NO: 95), CDRL2 (SEQ ID NO: 96), and CDRL3 (SEQ ID NO: 97) according to the classification of Thornton et al. (J. Mol. Biol., 263, 800-815, (1996)) and the H3 rules (FEBS letters 399, 1-8 (1996)), 2HOJ, 1BBD, 1Q9O, 2FBJ, 1LNK, and 1TET were selected, respectively, and incorporated in the framework model.

[0187]

Finally, in order to obtain a possible molecular model of the M30 variable region in terms of energy, an energy calculation was performed for excluding disadvantageous interatomic contact. The above procedure was carried out using the commercially available protein tertiary structure prediction program Prime and the coordinate search program MacroModel (Schrodinger, LLC).

9)-1-2 Designing of amino acid sequence of humanized M30

A humanized M30 antibody was constructed according to a method generally known as CDR grafting (Proc. Natl. Acad. Sci. USA 86, 10029-10033 (1989)).

An acceptor antibody was selected based on the amino acid homology within the framework region. The sequence of the framework region of M30 was compared with all human framework

sequences in the Kabat Database (Nuc. Acid Res. 29, 205-206 (2001)) of antibody amino acid sequences. As a result, a mAb49'CL antibody (GenBank in NCBI: D16838.1 and D16837.1) was selected as an acceptor based on a sequence homology of 70% in the framework region.

The amino acid residues in the framework region of mAb49'CL were aligned with the amino acid residues of M30, and the positions where different amino acids were used were identified. The positions of these residues were analyzed using the three-dimensional model of M30 constructed above. Then, donor residues to be grafted onto the acceptor were selected according to the criteria provided by Queen et al. (Proc. Natl. Acad. Sci. USA 86, 10029-10033 (1989)). By transferring some selected donor residues to the acceptor antibody, humanized M30 antibody sequences were constructed as described in the following Example.

9)-2 Humanization of M30 heavy chain

9)-2-1 M30-H1-type heavy chain:

A humanized M30 heavy chain designed by substituting amino acid numbers 20 (glutamic acid), 24 (glutamine), 28 (proline), 30 (leucine), 31 (valine), 35 (alanine), 39 (methionine), 57 (lysine), 59 (lysine), 67 (isoleucine), 86 (lysine), 87 (alanine), 89 (glutamine), 91 (serine), 93 (lysine), 95 (serine), 106 (threonine), 110 (serine), 136

(threonine), and 137 (leucine) of the cM30 heavy chain represented by SEQ ID NO: 63 in the Sequence Listing with glutamine, valine, alanine, valine, lysine, serine, valine, arginine, alanine, methionine, arginine, valine, isoleucine, alanine, glutamic acid, threonine, arginine, threonine, leucine, and valine, respectively, was named “M30-H1-type heavy chain”.

The amino acid sequence of the M30-H1-type heavy chain is represented by SEQ ID NO: 85.

9)-2-2 M30-H2-type heavy chain:

A humanized M30 heavy chain designed by substituting amino acid numbers 20 (glutamic acid), 24 (glutamine), 28 (proline), 30 (leucine), 31 (valine), 35 (alanine), 39 (methionine), 57 (lysine), 59 (lysine), 86 (lysine), 87 (alanine), 89 (glutamine), 91 (serine), 93 (lysine), 95 (serine), 106 (threonine), 110 (serine), 136 (threonine), and 137 (leucine) of the cM30 heavy chain represented by SEQ ID NO: 63 in the Sequence Listing with glutamine, valine, alanine, valine, lysine, serine, valine, arginine, alanine, arginine, valine, isoleucine, alanine, glutamic acid, threonine, arginine, threonine, leucine, and valine, respectively, was named “M30-H2-type heavy chain”.

The amino acid sequence of the M30-H2-type heavy chain is represented by SEQ ID NO: 87.

9)-2-3 M30-H3-type heavy chain:

A humanized M30 heavy chain designed by substituting amino acid numbers 24 (glutamine), 28 (proline), 30 (leucine), 31 (valine), 35 (alanine), 39 (methionine), 59 (lysine), 89 (glutamine), 91 (serine), 93 (lysine), 95 (serine), 106 (threonine), 110 (serine), 136 (threonine), and 137 (leucine) of the cM30 heavy chain represented by SEQ ID NO: 63 in the Sequence Listing with valine, alanine, valine, lysine, serine, valine, alanine, isoleucine, alanine, glutamic acid, threonine, arginine, threonine, leucine, and valine, respectively, was named “M30-H3-type heavy chain”.

The amino acid sequence of the M30-H3-type heavy chain is represented by SEQ ID NO: 89.

9)-2-4 M30-H4-type heavy chain:

A humanized M30 heavy chain designed by substituting amino acid numbers 24 (glutamine), 28 (proline), 30 (leucine), 31 (valine), 35 (alanine), 39 (methionine), 59 (lysine), 95 (serine), 106 (threonine), 110 (serine), 136 (threonine), and 137 (leucine) of the cM30 heavy chain represented by SEQ ID NO: 63 in the Sequence Listing with valine, alanine, valine, lysine, serine, valine, alanine, threonine, arginine, threonine, leucine, and valine, respectively, was named “M30-H4-type heavy chain”.

The amino acid sequence of the M30-H4-type heavy chain is represented by SEQ ID NO: 91.

9)-3 Humanization of M30 light chain

9)-3-1 M30-L1-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 21 (glutamine), 25 (serine), 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 42 (threonine), 61 (serine), 62 (serine), 64 (lysine), 65 (proline), 66 (tryptophan), 77 (valine), 89 (serine), 90 (tyrosine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with glutamic acid, threonine, alanine, threonine, leucine, arginine, alanine, leucine, serine, glutamine, alanine, arginine, leucine, leucine, isoleucine, aspartic acid, phenylalanine, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L1-type light chain”.

The amino acid sequence of the M30-L1-type light chain is represented by SEQ ID NO: 71.

9)-3-2 M30-L2-type light chain:

A humanized M30 light chain designed by substituting

amino acid numbers 21 (glutamine), 25 (serine), 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 42 (threonine), 61 (serine), 62 (serine), 64 (lysine), 65 (proline), 77 (valine), 89 (serine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with glutamic acid, threonine, alanine, threonine, leucine, arginine, alanine, leucine, serine, glutamine, alanine, arginine, leucine, isoleucine, aspartic acid, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L2-type light chain”.

The amino acid sequence of the M30-L2-type light chain is represented by SEQ ID NO: 73.

9)-3-3 M30-L3-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 62 (serine), 65 (proline), 77 (valine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with alanine, threonine, leucine, arginine, alanine, leucine,

alanine, leucine, isoleucine, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L3-type light chain”.

The amino acid sequence of the M30-L3-type light chain is represented by SEQ ID NO: 75.

9)-3-4 M30-L4-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 21 (glutamine), 25 (serine), 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 42 (threonine), 61 (serine), 62 (serine), 64 (lysine), 66 (tryptophan), 77 (valine), 89 (serine), 90 (tyrosine), 91 (serine), 96 (arginine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with glutamic acid, threonine, alanine, threonine, leucine, arginine, alanine, leucine, serine, glutamine, alanine, arginine, leucine, isoleucine, aspartic acid, phenylalanine, threonine, serine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L4-type light chain”.

The amino acid sequence of the M30-L4-type light chain is represented by SEQ ID NO: 77.

9)-3-5 M30-L5-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 62 (serine), 77 (valine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with alanine, threonine, leucine, arginine, alanine, leucine, alanine, isoleucine, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L5-type light chain”.

The amino acid sequence of the M30-L5-type light chain is represented by SEQ ID NO: 79.

9)-3-6 M30-L6-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 21 (glutamine), 25 (serine), 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 42 (threonine), 61 (serine), 62 (serine), 64 (lysine), 66 (tryptophan), 77 (valine), 89 (serine), 90 (tyrosine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with glutamic acid, threonine,

alanine, threonine, leucine, arginine, alanine, leucine, serine, glutamine, alanine, arginine, leucine, isoleucine, aspartic acid, phenylalanine, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L6-type light chain”.

The amino acid sequence of the M30-L6-type light chain is represented by SEQ ID NO: 81.

9)-3-7 M30-L7-type light chain:

A humanized M30 light chain designed by substituting amino acid numbers 21 (glutamine), 25 (serine), 29 (threonine), 30 (isoleucine), 33 (alanine), 38 (lysine), 39 (valine), 41 (methionine), 42 (threonine), 61 (serine), 62 (serine), 64 (lysine), 66 (tryptophan), 77 (valine), 89 (serine), 91 (serine), 97 (valine), 99 (alanine), 102 (alanine), 104 (threonine), 119 (threonine), 123 (leucine), and 125 (leucine) of the cM30 light chain represented by SEQ ID NO: 59 in the Sequence Listing with glutamic acid, threonine, alanine, threonine, leucine, arginine, alanine, leucine, serine, glutamine, alanine, arginine, leucine, isoleucine, aspartic acid, threonine, leucine, proline, phenylalanine, valine, glutamine, valine, and isoleucine, respectively, was named “M30-L7-type light chain”.

The amino acid sequence of the M30-L7-type light chain is represented by SEQ ID NO: 83.

(Example 10) Production of humanized antibody

10)-1 Construction of M30-L1, M30-L2, M30-L3, M30-L4, M30-L5, M30-L6, and M30-L7-type light chain expression vectors

DNAs comprising a gene encoding an M30-L1, M30-L2, M30-L3, M30-L4, M30-L5, M30-L6, or M30-L7-type light chain variable region represented by amino acid numbers 21 to 128 in SEQ ID NO: 71, amino acid numbers 21 to 128 in SEQ ID NO: 73, amino acid numbers 21 to 128 in SEQ ID NO: 75, amino acid numbers 21 to 128 in SEQ ID NO: 77, amino acid numbers 21 to 128 in SEQ ID NO: 79, amino acid numbers 21 to 128 in SEQ ID NO: 81, or amino acid numbers 21 to 128 in SEQ ID NO: 83 in the Sequence Listing were synthesized (GENEART, Inc. Artificial Gene Synthesis Service) based on SEQ ID NOS: 70, 72, 74, 76, 78, 80, and 82 according to the nucleotide sequences corresponding to the above SEQ ID NOS according to the amino acid sequences. Then, each of the DNA fragments obtained by cleaving the synthesized DNAs with the restriction enzymes NdeI and BsiWI was inserted into the universal chimeric and humanized antibody light chain expression vector (pEF6KCL) at the site cleaved with the restriction enzymes NdeI and BsiWI, whereby M30-L1, M30-L2, M30-L3, M30-L4, M30-L5, M30-L6, and M30-L7-type light chain expression vectors were constructed.

The thus obtained expression vectors were named “pEF6KCL/M30-L1”, “pEF6KCL/M30-L2”, “pEF6KCL/M30-L3”,

“pEF6KCL/M30-L4”, “pEF6KCL/M30-L5”, “pEF6KCL/M30-L6”, and “pEF6KCL/M30-L7”, respectively.

10)-2 Construction of M30-H1, M30-H2, M30-H3, and M30-H4-type heavy chain expression vectors

DNAs comprising a gene encoding an M30-H1, M30-H2, M30-H3, or M30-H4-type heavy chain variable region represented by amino acid numbers 20 to 141 in SEQ ID NO: 85, amino acid numbers 20 to 141 in SEQ ID NO: 87, amino acid numbers 20 to 141 in SEQ ID NO: 89, or amino acid numbers 20 to 141 in SEQ ID NO: 91 in the Sequence Listing were synthesized (GENEART, Inc. Artificial Gene Synthesis Service) based on SEQ ID NO: 84, 86, 88, and 90 according to the nucleotide sequences corresponding to the above SEQ ID NOS according to the amino acid sequences. Then, each of the DNA fragments obtained by cleaving the synthesized DNAs with the restriction enzyme BlpI was inserted into the universal humanized antibody heavy chain expression vector (pEF1FCCU) at the site cleaved with the restriction enzyme BlpI, whereby M30-H1, M30-H2, M30-H3, and M30-H4-type heavy chain expression vectors were constructed.

The thus obtained expression vectors were named “pEF1FCCU/M30-H1”, “pEF1FCCU/M30-H2”, “pEF1FCCU/M30-H3”, and “pEF1FCCU/M30-H4”, respectively.

10)-3 Production of humanized antibody

1.2×10^9 cells of FreeStyle 293F cells (Invitrogen Corporation) in the logarithmic growth phase were seeded into 1.2 L of fresh FreeStyle 293 Expression Medium (Invitrogen Corporation) and cultured for 1 hour by shaking at 90 rpm at 37°C in an 8% CO_2 incubator. 3.6 mg of polyethyleneimine (Polyscience #24765) was dissolved in 20 ml of Opti-Pro SFM medium (Invitrogen Corporation). Subsequently, a heavy chain expression vector (0.4 mg) and a light chain expression vector (0.8 mg) prepared with PureLink HiPure Plasmid Kit (Invitrogen Corporation) were suspended in 20 ml of Opti-Pro SFM medium. Then, 20 ml of the obtained expression vectors/Opti-Pro SFM mixed liquid was added to 20 ml of the obtained polyethyleneimine/Opti-Pro SFM mixed liquid, and the resulting mixture was gently stirred and then left for 5 minutes. Thereafter, the mixture was added to the FreeStyle 293F cells, and shaking culture at 90 rpm was performed for 7 days at 37°C in an 8% CO_2 incubator. The resulting culture supernatant was filtered through a disposable capsule filter (Advantec #CCS-045-E1H).

A humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L1 was named “M30-H1-L1”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L2 was named “M30-H1-L2”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L3 was named “M30-H1-L3”, a

humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L4 was named “M30-H1-L4”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H4 and pEF6KCL/M30-L1 was named “M30-H4-L1”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H4 and pEF6KCL/M30-L2 was named “M30-H4-L2”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H4 and pEF6KCL/M30-L3 was named “M30-H4-L3”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H4 and pEF6KCL/M30-L4 was named “M30-H4-L4”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L5 was named “M30-H1-L5”, a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L6 was named “M30-H1-L6”, and a humanized antibody of M30 obtained by a combination of pEF1FCCU/M30-H1 and pEF6KCL/M30-L7 was named “M30-H1-L7”.

10)-4 Purification of humanized antibody

The culture supernatant obtained in Example 10)-3 was purified by a two-step process including rProtein A affinity chromatography (at 4 to 6°C) and ceramic hydroxyapatite (at room temperature). A buffer exchange step after the purification by rProtein A affinity chromatography and after the purification by ceramic hydroxyapatite was performed at room temperature.

First, 1100 to 1200 ml of the culture supernatant was applied to MabSelect SuRe (manufactured by GE Healthcare Bio-Sciences Co., Ltd., two HiTrap columns (volume: 1 ml) connected in series) equilibrated with PBS. After all culture solution was poured into the column, the column was washed with 15 to 30 ml of PBS. Subsequently, elution was performed with a 2 M arginine hydrochloride solution (pH 4.0), and a fraction containing the antibody was collected. The fraction was applied to a desalting column (manufactured by GE Healthcare Bio-Sciences Co., Ltd., two HiTrap desalting columns (volume: 5 ml) connected in series), whereby the buffer was exchanged with a buffer containing 5 mM sodium phosphate, 50 mM MES, and 20 mM NaCl at pH 6.5.

Further, the antibody solution subjected to buffer exchange was applied to a ceramic hydroxyapatite column (Japan Bio-Rad Laboratories, Inc., Bio-Scale CHT2-1 hydroxyapatite column (volume: 2 ml)) equilibrated with a buffer containing 5 mM NaPi, 50 mM MES, and 20 mM NaCl at pH 6.5. Then, linear concentration gradient elution with sodium chloride was performed, and a fraction containing the antibody was collected.

The fraction was applied to a desalting column (manufactured by GE Healthcare Bio-Sciences Co., Ltd., two HiTrap desalting columns (volume: 5 ml) connected in series), whereby the liquid was exchanged with CBS (containing 10 mM

citrate buffer and 140 mM sodium chloride, pH 6.0).

Finally, the resulting solution was concentrated using Centrifugal UF Filter Device VIVASPIN 20 (fractional molecular weight: 30 K, Sartorius Co., Ltd., at 4°C), and the concentration of IgG was adjusted to 1.0 mg/ml or more, and the thus obtained solution was used as a purified sample.

10)-5 Binding property of humanized antibody to B7-H3 antigen

The binding property of the humanized M30 antibody to human B7-H3 which is an antigen was measured by a surface plasmon resonance (SPR) device (Biacore, Inc.). According to common procedures, an anti-human IgG antibody was immobilized on a sensor chip, and then, each of the purified samples of the humanized M30 antibodies obtained in the above 10)-4 was bound thereto. Thereafter, an extracellular domain polypeptide of the B7-H3 variant 2 antigen (manufactured by R&D Systems, Inc., #2318-B3-050/CF) was added thereto at different concentrations, and the amount of the antigen bound to the antibody in a running buffer (phosphate buffer, 0.05% SP20) was measured over time. The measured amount was analyzed with dedicated software (BIAevaluation) and a dissociation constant (Kd [M]) was calculated. The measurement was performed using the cM30 antibody as a positive control for each measurement operation. The results are as shown in Table 3. All of the humanized M30 antibodies had binding activity

against the B7-H3 antigen.

[0188]

[Table 3]

	Kd [M]
M30-H1-L1	8.7E-08
M30-H1-L2	1.0E-07
M30-H1-L3	1.0E-07
M30-H1-L4	1.6E-08
M30-H4-L1	1.3E-07
M30-H4-L2	1.4E-07
M30-H4-L3	1.6E-07
M30-H4-L4	1.2E-08
M30-H1-L5	1.9E-09
M30-H1-L6	3.4E-09
M30-H1-L7	2.7E-09
cM30	7.3E-10

[0189]

Example 11. Measurement of competitive inhibitory activities of cM30 antibody and humanized M30 antibody against M30 antibody for the binding to B7-H3 antigen

The competitive inhibitory activities of the cM30 antibody and the humanized M30 antibody (M30-H1-L4 antibody) against the M30 antibody for the binding to the B7-H3 variant 1 and variant 2 were measured by the following method.

[0190]

By using EZ-Link Sulfo-NHS-LC Biotinylation Kit (manufactured by Thermo Scientific Corporation, #21435) and according to the attached protocol, the respective mouse monoclonal antibodies M30 were biotinylated (hereinafter the respective biotinylated M30 antibodies were referred to as "bM30"). Further, as a buffer to be used in the following ELISA

method, BD OPTI EIA (BD Biosciences, Inc., #550536) was used in all cases.

Each of the extracellular domain polypeptide of the B7-H3 variant 1 (manufactured by R&D Systems, Inc., #1949-B3-050/CF) and the extracellular domain polypeptide of the B7-H3 variant 2 (manufactured by R&D Systems, Inc., #2318-B3-050/CF) was diluted to 0.5 μg/ml with a coating buffer and the resulting solution was dispensed at 100 μL/well in an immunoplate (manufactured by Nunc, Inc., #442404). Then, the plate was left to stand overnight at 4°C, whereby the protein was adsorbed to the plate. On the next day, an assay diluent was dispensed at 200 μL/well, and the plate was left to stand at room temperature for 4 hours.

After the solution in each well was removed, a mixed solution of the biotinylated antibody at 5 μg/ml and an unlabeled antibody at each concentration (0 μg/ml, 1 μg/ml, 5μg/ml, 25 μg/ml, 50 μg/ml, or 125 μg/ml) was dispensed at 100 μL/well in an assay diluent, and the plate was left to stand at room temperature for 1 hour.

After each well was washed twice with a wash buffer, a streptavidin-horseradish peroxidase conjugate (manufactured by GE Healthcare Bio-Sciences Corporation, #RPN1231V) diluted to 500-fold with an assay diluent was added at 100 μL/well, and the plate was left to stand at room temperature for 1 hour.

After the solution in each well was removed and each well

was washed twice with a wash buffer, a substrate solution was added at 100 μL/well, and a color development reaction was allowed to proceed while stirring the reaction mixture. After completion of the color development, a blocking buffer was added thereto at 100 μl/well to stop the color development reaction. Then, an absorbance at 450 nm was measured using a plate reader.

[0191]

As a result, the absorbance of the well to which only bM30 was added was 2.36 ± 0.05 (mean ± standard deviation (n=12)) in the plate to which the polypeptide of the extracellular domain of the B7-H3 variant 1 was attached, and 1.90 ± 0.20 (mean ± standard deviation (n=12)) in the plate to which the polypeptide of the extracellular domain of the B7-H3 variant 2 was attached.

[0192]

The absorbances in the graphs of Fig. 10 are each expressed as a mean ± standard deviation (n=3). The control IgG did not inhibit the binding of bM30 to B7-H3.

On the other hand, it was shown that the binding of bM30 to B7-H3 is inhibited by the M30 antibody itself, the cM30 antibody, which is a chimeric antibody of the M30 antibody, and the M30-H1-L4, which is a humanized antibody, in both of the plate to which the polypeptide of the extracellular domain of the B7-H3 variant 1 was attached and the plate to which the

polypeptide of the extracellular domain of the B7-H3 variant 2 was attached.

[0193]

That is, it was shown that the cM30 antibody and the humanized antibody (M30-H1-L4 antibody) recognize the same epitope of the B7-H3 antigen as the M30 antibody.

Example 12. Activity of humanized M30 antibody

12)-1 ADCP activity of humanized M30 antibody

PBMCs of a healthy subject were isolated according to common procedures and suspended in 10% FBS-containing RPMI 1640 and then seeded in a flask. The cells were cultured overnight in a CO_2 incubator. The culture supernatant was removed, and to the cells attached to the flask, 10% FBS-containing RPMI 1640 supplemented with M-CSF and GM-CSF (PeproTech, Inc.) was added, and the cells were cultured for 2 weeks. The cells were detached with TrypLE and collected. Then, the cells were added to a 24-well plate at 500 μl/well (1×10^5 cells/well) and cultured overnight at 37°C. The thus prepared cells were used as effector cells.

The labeling of NCI-H322 cells to be used as target cells was performed using PKH26 dye labeling kit (Sigma Co., Ltd.). The target cells were detached with TrypLE and washed twice with PBS. The cells were suspended in Diluent C at 1×10^7 cells/ml. PKH26 dye stock (1 mM) was diluted to 8 μM with Diluent C, and immediately thereafter, the diluted dye solution

was added thereto in an amount equal to that of the cell suspension. The resulting mixture was left at room temperature for 5 minutes. Then, 1 ml of serum was added thereto, and further, a medium with serum was added thereto, and washing was performed twice.

[0194]

Each of the M30 antibody, the cM30 antibody, and the humanized M30 antibody (M30-H1-L4 antibody) was diluted to 20 μg/ml with 10% FBS-containing RPMI 1640 (Invitrogen Corporation). Subsequently, the target cells (NCI-H322 cells) were dispensed at 2 x 10^6 cells/100 μl/tube and mixed. The resulting mixture was left to stand on ice for 30 minutes. The supernatant was removed, and the cells were washed twice with a culture solution and suspended in 500 μl of a culture solution.

The supernatant was removed from the effector cells, and the cells having been treated with the M30 antibody, the cM30 antibody, or the humanized M30 antibody (M30-H1-L4 antibody) and suspended in the culture solution were added thereto and mixed therewith. Then, the cells were cultured for 3 hours in a CO_2 incubator.

Thereafter, the cells were detached with Trypsin-EDTA and collected.

To the collected cells, an FITC-labeled anti-mouse CD11b antibody (Becton, Dickinson and Company, Ltd.) was added, and the resulting mixture was left to stand on ice for 30 minutes.

The supernatant was removed, and the cells were washed twice with a culture solution.

The collected cells were suspended in 300 μl of a culture medium and analyzed by FACS Calibur (Becton, Dickinson and Company, Ltd.). In the CD11b-positive macrophages, a PKH26-positive fraction was evaluated as phagocytosis-positive cells.

[0195]

The results are shown in Fig. 11.

In the group with the addition of the humanized M30 antibody (M30-H1-L4 antibody), ADCP activity against the NCI-H322 cells was observed in the same manner as in the groups with the addition of the M30 antibody or the cM30 antibody.

12)-2 ADCC activity of humanized M30 antibody

PBMCs of a healthy subject were isolated according to common procedures and suspended in 10% FBS-containing RPMI 1640 and then seeded in a flask. The cells were cultured overnight in a CO_2 incubator.

The floating cells were collected, followed by a washing procedure, and the resulting cells were used as peripheral blood lymphocytes (PBLs). The obtained PBLs were suspended in phenol red-free RPMI 1640 (manufactured by Invitrogen Corporation) containing 10% Fetal Bovine Serum (manufactured by Invitrogen Corporation) (hereinafter abbreviated as “ADCC

medium"), and the cell suspension was passed through a cell strainer (pore size: 40 μm, manufactured by BD Biosciences, Ltd.). Then, the viable cells were counted by a trypan blue dye exclusion assay. After the PBLs suspension was centrifuged, the medium was removed, and the cells were resuspended in the ADCC medium at a viable cell density of 2.5 x 10^6 cells/ml and used as effector cells.

[0196]

NCI-H322 cells were treated with trypsin, and the treated cells were washed with 10% FBS-containing RPMI 1640 and then resuspended in 10% FBS-containing RPMI 1640. The cells (4 x 10^6 cells) were mixed with chromium-51 (5550 kBq) sterilized through a 0.22 μm filter, and labeling was performed for 1 hour under the conditions of 37°C and 5% CO_2. The labeled cells were washed three times with the ADCC medium, and the cells were resuspended at 2 x 10^5 cells/ml in the ADCC medium and used as target cells.

The target cells at a cell density of 2 x 10^5 cells/ml were dispensed at 50 μl/well in a 96-well U-shaped bottom microplate. 50 μl of each of the cM30 antibody and the humanized M30 antibodies (M30-H1-L4, M30-H4-L4, M30-H1-L5, M30-H1-L6, and M30-H1-L7) was added thereto, diluted with the ADCC medium so that the final concentration of the antibody after adding the effector cells was 1, 10, 100, or 1000 ng/ml. Then, 100 μl of the effector cells at a cell density of 2.5

x 10^6 cells/ml were added thereto, and the cells were cultured for 4 hours under the conditions of 37°C and 5% CO_2. The supernatant was collected in a LumaPlate (manufactured by PerkinElmer, Inc.), and gamma radiation emitted therefrom was measured using a gamma counter. The percentage of cell lysis caused by the ADCC activity was calculated according to the following equation.

[0197]

Percentage of cell lysis (%) = (A–B) / (C–B) x 100

A: Radiation count from the sample well

B: Average spontaneous radiation emission count (from wells to which the antibody and the effector cells were not added) (n=3). The same procedure as that for the sample well was performed except that the ADCC medium was added in an amount of 50 μl at the time of adding the antibody and in an amount of 100 μl at the time of adding the effector cells.

[0198]

C: Average maximum radiation emission count (from wells in which the target cells were dissolved with a surfactant) (n=3). The same procedure as that for the sample well was performed except that 50 μl of the ADCC medium was added at the time of adding the antibody and 100 μl of the ADCC medium containing 2% (v/v) Triton X–100 was added at the time of adding the effector cells.

[0199]

The results are shown in Table 4 and Fig. 12.

The data shown are an average of triplicate measurements, and the error bars represent standard deviations. The P value was calculated using Student's t-test.

In the group with the addition of the M30-H1-L4 antibody, ADCC activity was observed in the same manner as in the group with the addition of the cM30 antibody. Also other humanized M30 antibodies (M30-H4-L4, M30-H1-L5, M30-H1-L6, and M30-H1-L7) were observed to have ADCC activity in the same manner.

[0200]

[Table 4]

	1 ng/mL		10 ng/mL		100 ng/mL		1000 ng/mL	
	Average (%)	Standard deviation	Average (%)	Standard deviation	Average (%)	Standard deviation	Average (%)	Standard deviation
human IgG	3.8	1.6	6.8	1.5	3.9	1.4	6.5	0.5
cM30	11.1	1.2	40.5	2.7	84.3	2.3	88.2	4.0
M30-H1-L4	11.5	1.0	43.1	0.1	83.6	0.7	84.7	1.0
M30-H4-L4	7.6	1.1	26.6	1.6	68.9	2.6	81.7	1.5
M30-H1-L5	9.6	1.1	30.5	2.0	67.8	5.0	78.8	3.0
M30-H1-L6	9.8	1.6	32.0	2.2	74.7	4.0	81.3	2.0
M30-H1-L7	8.3	0.7	29.4	0.7	71.7	2.0	80.7	0.7

[0201]

12)-3 In vivo antitumor effect of humanized M30 antibody

MDA-MB-231 cells were detached from a culture flask by a trypsin treatment, and then suspended in 10% FBS-containing RPMI 1640 medium (Life Technologies Corporation), followed by centrifugation and the supernatant was removed. The cells

were washed twice with the same medium, and then suspended in BD Matrigel Basement Membrane Matrix (manufactured by BD Biosciences, Inc.). Then, the cells were implanted subcutaneously in the axillary region of each of a group of mice (FOX CHASE SCID C.B.17/Icr-scid/scidJcl, CLEA Japan, Inc.) at 6 weeks of age at a dose of 5×10^6 cells/mouse. The day of implantation was taken as day 0, and on days 14, 21, 28, 35, and 42, the humanized M30 antibody (M30-H1-L4 antibody) was intraperitoneally administered at a dose of 10, 1, 0.1, or 0.01 mg/kg (about 200, 20, 2, or 0.2 μg/mouse, respectively). The tumor volume was measured on days 14, 18, 21, 25, 28, 31, 35, 39, 42, 45, and 49, and the antitumor effect of the administration of the antibody was examined.

As a result, in the groups of administration of the humanized M30 antibody (M30-H1-L4 antibody) at 10, 1, and 0.1 mg/kg, the tumor growth was significantly suppressed as compared with the untreated group in which the antibody was not administered. In the groups of administration of the humanized M30 antibody (M30-H1-L4 antibody) at 10, 1, and 0.1 mg/kg, the tumor growth inhibition ratio (= 100 - (average tumor weight in antibody administration group) / (average tumor weight in untreated group) x 100) compared with the untreated group in terms of the tumor weight on day 49 was 67, 54, and 51%, respectively, and the P values were all $P<0.0001$. The P values were calculated using Dunnett's multiple comparison

test.

Further, the tumor growth inhibition ratio (%) (= 100 - (average tumor volume in antibody administration group) / (average tumor volume in untreated group) x 100) of the M30-H1-L4 antibody on day 49 in the 10, 1, 0.1, and 0.01 mg/kg administration groups was 84, 68, 61, and 30%, respectively. Accordingly, the humanized M30 antibody (M30-H1-L4 antibody) was observed to have a very strong antitumor effect in vivo in the same manner as the M30 antibody and the cM30 antibody, and it was confirmed that the effect was exhibited in a dose-response manner (Fig. 38).

Industrial Applicability

[0202]

The anti-B7-H3 antibody of the invention has antitumor activity, and a pharmaceutical composition comprising the anti-B7-H3 antibody can be an anticancer agent.

Sequence Listing Free Text

[0203]

SEQ ID NO: 1: PCR primer 1

SEQ ID NO: 2: PCR primer 2

SEQ ID NO: 3: CMV promoter primer: primer 3

SEQ ID NO: 4: BGH reverse primer: primer 4

SEQ ID NO: 5: nucleotide sequence of B7-H3 variant 1

SEQ ID NO: 6: amino acid sequence of B7-H3 variant 1

SEQ ID NO: 7: PCR primer 5

SEQ ID NO: 8: PCR primer 6

SEQ ID NO: 9: nucleotide sequence of B7-H3 variant 2

SEQ ID NO: 10: amino acid sequence of B7-H3 variant 2

SEQ ID NO: 11: PCR primer 7

SEQ ID NO: 12: PCR primer 8

SEQ ID NO: 13: PCR primer 9

SEQ ID NO: 14: PCR primer 10

SEQ ID NO: 15: PCR primer 11

SEQ ID NO: 16: PCR primer 12

SEQ ID NO: 17: PCR primer 13

SEQ ID NO: 18: PCR primer 14

SEQ ID NO: 19: PCR primer 15

SEQ ID NO: 20: nucleotide sequence of B7-H3 IgV1

SEQ ID NO: 21: amino acid sequence of B7-H3 IgV1

SEQ ID NO: 22: nucleotide sequence of B7-H3 IgC1

SEQ ID NO: 23: amino acid sequence of B7-H3 IgC1

SEQ ID NO: 24: nucleotide sequence of B7-H3 IgV2

SEQ ID NO: 25: amino acid sequence of B7-H3 IgV2

SEQ ID NO: 26: nucleotide sequence of B7-H3 IgC2

SEQ ID NO: 27: amino acid sequence of B7-H3 IgC2

SEQ ID NO: 28: nucleotide sequence of B7-H3 IgC1-V2-C2

SEQ ID NO: 29: amino acid sequence of B7-H3 IgC1-V2-C2

SEQ ID NO: 30: nucleotide sequence of B7-H3 IgV2-C2

SEQ ID NO: 31: amino acid sequence of B7-H3 IgV2-C2

SEQ ID NO: 32: nucleotide sequence of B7RP-1

SEQ ID NO: 33: amino acid sequence of B7RP-1

SEQ ID NO: 34: nucleotide sequence of B7-H1

SEQ ID NO: 35: amino acid sequence of B7-H1

SEQ ID NO: 36: nucleotide sequence of B7-DC

SEQ ID NO: 37: amino acid sequence of B7-DC

SEQ ID NO: 38: nucleotide sequence of CD80

SEQ ID NO: 39: amino acid sequence of CD80

SEQ ID NO: 40: nucleotide sequence of CD86

SEQ ID NO: 41: amino acid sequence of CD86

SEQ ID NO: 42: nucleotide sequence of B7-H4

SEQ ID NO: 43: amino acid sequence of B7-H4

SEQ ID NO: 44: N-terminal amino acid sequence of mouse antibody M30 heavy chain

SEQ ID NO: 45: N-terminal amino acid sequence of mouse antibody M30 light chain

SEQ ID NO: 46: PCR primer 16

SEQ ID NO: 47: PCR primer 17

SEQ ID NO: 48: PCR primer 18

SEQ ID NO: 49: PCR primer 19

SEQ ID NO: 50: nucleotide sequence of cDNA encoding M30 antibody heavy chain

SEQ ID NO: 51: amino acid sequence of M30 antibody heavy chain

SEQ ID NO: 52: nucleotide sequence of cDNA encoding M30 antibody

light chain

SEQ ID NO: 53: amino acid sequence of M30 antibody light chain

SEQ ID NO: 54: PCR primer 20

SEQ ID NO: 55: PCR primer 21

SEQ ID NO: 56: DNA sequence encoding human κ chain secretory signal, human κ chain constant region, and human poly-A additional signal

SEQ ID NO: 57: DNA fragment comprising DNA sequence encoding amino acids of signal sequence and constant region of human IgG1

SEQ ID NO: 58: nucleotide sequence of cDNA encoding M30 antibody chimera-type light chain

SEQ ID NO: 59: amino acid sequence of M30 antibody chimera-type light chain

SEQ ID NO: 60: PCR primer 22

SEQ ID NO: 61: PCR primer 23

SEQ ID NO: 62: nucleotide sequence of cDNA encoding M30 antibody chimera-type heavy chain

SEQ ID NO: 63: amino acid sequence of M30 antibody chimera-type heavy chain

SEQ ID NO: 64: PCR primer 24

SEQ ID NO: 65: PCR primer 25

SEQ ID NO: 66: PCR primer 26

SEQ ID NO: 67: PCR primer 27

SEQ ID NO: 68: PCR primer 28

SEQ ID NO: 69: PCR primer 29

SEQ ID NO: 70: nucleotide sequence of M30-L1-type light chain

SEQ ID NO: 71: amino acid sequence of M30-L1-type light chain

SEQ ID NO: 72: nucleotide sequence of M30-L2-type light chain

SEQ ID NO: 73: amino acid sequence of M30-L2-type light chain

SEQ ID NO: 74: nucleotide sequence of M30-L3-type light chain

SEQ ID NO: 75: amino acid sequence of M30-L3-type light chain

SEQ ID NO: 76: nucleotide sequence of M30-L4-type light chain

SEQ ID NO: 77: amino acid sequence of M30-L4-type light chain

SEQ ID NO: 78: nucleotide sequence of M30-L5-type light chain

SEQ ID NO: 79: amino acid sequence of M30-L5-type light chain

SEQ ID NO: 80: nucleotide sequence of M30-L6-type light chain

SEQ ID NO: 81: amino acid sequence of M30-L6-type light chain

SEQ ID NO: 82: nucleotide sequence of M30-L7-type light chain

SEQ ID NO: 83: amino acid sequence of M30-L7-type light chain

SEQ ID NO: 84: nucleotide sequence of M30-H1-type heavy chain

SEQ ID NO: 85: amino acid sequence of M30-H1-type heavy chain

SEQ ID NO: 86: nucleotide sequence of M30-H2-type heavy chain

SEQ ID NO: 87: amino acid sequence of M30-H2-type heavy chain

SEQ ID NO: 88: nucleotide sequence of M30-H3-type heavy chain

SEQ ID NO: 89: amino acid sequence of M30-H3-type heavy chain

SEQ ID NO: 90: nucleotide sequence of M30-H4-type heavy chain

SEQ ID NO: 91: amino acid sequence of M30-H4-type heavy chain

SEQ ID NO: 92: amino acid sequence of M30 antibody CDRH1

SEQ ID NO: 93: amino acid sequence of M30 antibody CDRH2

SEQ ID NO: 94: amino acid sequence of M30 antibody CDRH3

SEQ ID NO: 95: amino acid sequence of M30 antibody CDRL1

SEQ ID NO: 96: amino acid sequence of M30 antibody CDRL2

SEQ ID NO: 97: amino acid sequence of M30 antibody CDRL3

Claims

1. An antibody or a functional fragment of the antibody characterized by having the following properties of:

(a) specifically binding to B7-H3;

(b) having an antibody-dependent cell-mediated phagocytosis (ADCP) activity; and

(c) having an in vivo antitumor activity,

wherein B7-H3 is a molecule comprising an amino acid sequence represented by SEQ ID NO: 6 or 10, and wherein the antibody or the functional fragment of the antibody binds to IgC1 and/or IgC2 each of which is a domain of B7-H3.

2. The antibody or a functional fragment of the antibody according to claim 1, wherein IgC1 is a domain comprising an amino acid sequence represented by amino acid numbers 140 to 244 in SEQ ID NO: 6, and IgC2 is a domain comprising an amino acid sequence represented by amino acid numbers 358 to 456 in SEQ ID NO: 6.

3. The antibody or a functional fragment of the antibody according to any one of claims 1 to 2, which has a competitive inhibitory activity against M30 antibody for the binding to B7-H3.

4. The antibody or a functional fragment of the antibody

according to any one of claims 1 to 3, which has an antibody-dependent cellular cytotoxicity (ADCC) activity and/or a complement-dependent cytotoxicity (CDC) activity.

5. The antibody or a functional fragment of the antibody according to any one of claims 1 to 4, wherein the tumor is cancer.

6. The antibody or a functional fragment of the antibody according to claim 5, wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.

7. The antibody or a functional fragment of the antibody according to any one of claims 1 to 6, which comprises CDRH1 consisting of an amino acid sequence represented by SEQ ID NO: 92, CDRH2 consisting of an amino acid sequence represented by SEQ ID NO: 93, and CDRH3 consisting of an amino acid sequence represented by SEQ ID NO: 94 as complementarity determining regions of the heavy chain and comprises CDRL1 consisting of an amino acid sequence represented by SEQ ID NO: 95, CDRL2 consisting of an amino acid sequence represented by SEQ ID NO: 96, and CDRL3 consisting of an amino acid sequence represented by SEQ ID NO: 97 as complementarity determining regions of the

light chain.

8. The antibody or a functional fragment of the antibody according to any one of claims 1 to 7, which comprises a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 51 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 23 to 130 in SEQ ID NO: 53.

9. The antibody or a functional fragment of the antibody according to any one of claims 1 to 8, wherein a constant region is a human-derived constant region.

10. The antibody or a functional fragment of the antibody according to claim 9, which comprises a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 63 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 59.

11. The antibody or a functional fragment of the antibody according to any one of claims 1 to 10, which is humanized.

12. The antibody or a functional fragment of the antibody according to claim 11, which comprises: a heavy chain variable

region consisting of an amino acid sequence selected from the group consisting of (a) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85, (b) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 87, (c) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 89, (d) an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91, (e) an amino acid sequence having a homology of at least 95% or more with any of the sequences (a) to (d), and (f) an amino acid sequence wherein one or several amino acids are deleted, substituted or added in any of the sequences (a) to (d); and a light chain variable region consisting of an amino acid sequence selected from the group consisting of (g) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71, (h) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73, (i) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75, (j) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77, (k) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 79, (l) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 81, (m) an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 83, (n) an amino acid sequence having a homology of at least 95% or more with any of the sequences (g) to (m), and (o) an amino acid sequence

wherein one or several amino acids are deleted, substituted or added in any of the sequences (g) to (m).

13. The antibody or a functional fragment of the antibody according to claim 12, which comprises a heavy chain variable region and a light chain variable region selected from the group consisting of: a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers

20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 79; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 81; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 85 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 83; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 71; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 73; a heavy chain variable region consisting of an amino acid sequence represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 75; and a heavy chain variable region consisting of an amino acid sequence

represented by amino acid numbers 20 to 141 in SEQ ID NO: 91 and a light chain variable region consisting of an amino acid sequence represented by amino acid numbers 21 to 128 in SEQ ID NO: 77.

14. The antibody or a functional fragment of the antibody according to claim 12 or 13, which comprises a heavy chain and a light chain selected from the group consisting of: a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an

amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 79; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 81; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 83; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 75; and a heavy chain consisting of an amino acid sequence represented by amino acid numbers 20 to 471 in SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by amino acid numbers 21 to 233 in SEQ ID NO: 77.

15. The antibody or a functional fragment of the antibody according to any one of claims 12 to 14, which comprises a heavy chain and a light chain selected from the group consisting of: a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 71; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 75; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 77; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 79; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 81; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 85 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 83; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 71; a heavy chain consisting of an

amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 73; a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 75; and a heavy chain consisting of an amino acid sequence represented by SEQ ID NO: 91 and a light chain consisting of an amino acid sequence represented by SEQ ID NO: 77.

16. A polynucleotide encoding the antibody or a functional fragment of the antibody according to any one of claims 1 to 15.

17. The polynucleotide according to claim 16, which comprises a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 50 and a nucleotide sequence represented by nucleotide numbers 67 to 390 in SEQ ID NO: 52.

18. The polynucleotide according to claim 16 or 17, which comprises a nucleotide sequence represented by SEQ ID NO: 62 and a nucleotide sequence represented by SEQ ID NO: 58.

19. The polynucleotide according to claim 16 or 17, which comprises: a nucleotide sequence selected from the group consisting of (a) a nucleotide sequence represented by

nucleotide numbers 58 to 423 in SEQ ID NO: 84, (b) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 86, (c) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 88, (d) a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90, and (e) a nucleotide sequence comprising a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary to any of the nucleotide sequences (a) to (d) under stringent conditions; and a nucleotide sequence selected from the group consisting of (f) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70, (g) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72, (h) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74, (i) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76, (j) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 78, (k) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 80, (l) a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 82, and (m) a nucleotide sequence comprising a polynucleotide which hybridizes to a polynucleotide consisting of a nucleotide sequence complementary to any of the nucleotide sequences (f) to (l) under stringent conditions.

20. The polynucleotide according to claim 19, which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 78; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 80; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 82; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 70; a nucleotide sequence

represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 74; and a nucleotide sequence represented by nucleotide numbers 58 to 423 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 384 in SEQ ID NO: 76.

21. The polynucleotide according to claim 19 or 20, which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 74; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 76; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ

ID NO: 78; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 80; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 84 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 82; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 70; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 72; a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 74; and a nucleotide sequence represented by nucleotide numbers 58 to 1413 in SEQ ID NO: 90 and a nucleotide sequence represented by nucleotide numbers 61 to 699 in SEQ ID NO: 76.

22. The polynucleotide according to any one of claims 19 to 21, which comprises nucleotide sequences selected from the group consisting of: a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 70; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 72; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence

represented by SEQ ID NO: 74; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 76; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 78; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 80; a nucleotide sequence represented by SEQ ID NO: 84 and a nucleotide sequence represented by SEQ ID NO: 82; a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 70; a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 72; a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 74; and a nucleotide sequence represented by SEQ ID NO: 90 and a nucleotide sequence represented by SEQ ID NO: 76.

23. An expression vector comprising a polynucleotide according to any one of claims 16 to 22.

24. A host cell, which is transformed with the expression vector according to claim 23.

25. The host cell according to claim 24, wherein the host cell is a eukaryotic cell.

26. A method of producing an antibody or a functional fragment of the antibody, characterized by comprising a step of culturing the host cell according to claim 24 or 25 and a step of collecting a desired antibody or a functional fragment of the antibody from a cultured product obtained in the culturing step.

27. An antibody or a functional fragment of the antibody, characterized by being obtained by the production method according to claim 26.

28. The antibody or a functional fragment of the antibody according to any one of claims 1 to 15 and 27, wherein the modification of a glycan is regulated to enhance an antibody-dependent cellular cytotoxic activity.

29. A pharmaceutical composition characterized by comprising at least one of the antibodies or functional fragments of the antibodies according to claims 1 to 15, 27 and 28.

30. The pharmaceutical composition according to claim 29, which is for treating a tumor.

31. A pharmaceutical composition for treating a tumor

characterized by comprising at least one of the antibodies or functional fragments of the antibodies according to claims 1 to 15, 27 and 28 and at least one therapeutic agent for cancer.

32. The pharmaceutical composition according to claim 30 or 31, wherein the tumor is cancer.

33. The pharmaceutical composition according to claim 32, wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.

34. Use of an antibody or functional fragment of the antibody according to claims 1 to 15, 27 and 28 for the manufacture of a medicament for treating a tumor.

35. Use of an antibody or functional fragment of the antibody according to claims 1 to 15, 27 and 28 for the manufacture of a medicament for use in a method of treating a tumor wherein the method comprises administering the medicament and at least one therapeutic agent for cancer simultaneously, separately, or sequentially to an individual.

36. The use according to claim 34 or 35, wherein the tumor

is cancer.

37. The use according to claim 36, wherein the cancer is lung cancer, breast cancer, prostate cancer, pancreatic cancer, colorectal cancer, a melanoma, liver cancer, ovarian cancer, bladder cancer, stomach cancer, esophageal cancer, or kidney cancer.