REMEDY FOR GRAFT-VERSUS-HOST DISEASE COMPRISING INTERLEUKIN-6 RECEPTOR INHIBITOR AS THE ACTIVE INGREDIENT

The present invention provides a novel therapeutic agent for graft-versus-host disease (GVHD). A therapeutic agent for graft-versus-host disease (GVHD), which comprises an interleukin 6 (IL-6) receptor inhibitor as an active ingredient.
The present invention relates to therapeutic agents for graft-versus-host disease. More specifically, the present invention relates to therapeutic agents for graft-versus-host disease, which comprise an interleukin 6 (IL-6) receptor inhibitor as an active ingredient.

**BACKGROUND ART**

Although hematopoietic tumors such as leukemia are first treated by chemotherapy with anticancer agents, patients who are difficult to cure or less likely to be cured with standard chemotherapy further require transplantation of hematopoietic stem cells (e.g., peripheral blood stem cells, bone marrow cells). However, it is pointed out that transplantation of hematopoietic stem cells will cause graft-versus-host disease (GVHD).

GVHD is a generic name for diseases that are caused by the immune reaction of transferred or transplanted immunocompetent cells against host tissues. This would be mainly because immunocompetent cells (e.g., mature T cells) contained in peripheral blood to be transferred or transplanted will cause immune responses against recipient tissues. GVHD includes both acute and chronic types of diseases with symptoms such as skin symptoms, diarrhea and icterus, which can develop a severe effect leading to death in some cases.

Techniques conventionally used to suppress GVHD include those based on the use of immunosuppressive agents such as methotrexate or cyclosporin A, as well as those based on the removal of mature T cells from a group of transplant cells (graft). In the case of using methotrexate or cyclosporin A, a problem arises from their side effects on the body. Cyclosporin A is known to have a strong nephrotoxicity as a side effect, while methotrexate is known to cause bone marrow suppression as a side effect.

On the other hand, the removal of mature T cells from a group of transplant cells allows suppression of GVHD, but it has a drawback in that the antitumor effect becomes attenuated leading to, e.g., leukemia relapse (Non-patent Document 1).

Interleukin 6 (IL-6) is a cytokine called B cell stimulating factor 2 (BSF2) or interferon β2. IL-6 was discovered as a differentiation factor involved in activation of B cell lymphocytes (Non-patent Document 2), and was later revealed to be a multifunctional cytokine that influences the function of various cells (Non-patent Document 3). IL-6 has been reported to induce maturation of T lymphocyte cells (Non-patent Document 4).

IL-6 transmits its biological activity via two kinds of proteins on the cell. The first kind of protein is IL-6 receptor, which is a ligand-binding protein to which IL-6 binds; it has a molecular weight of about 80 kDa (Non-patent Documents 5 and 6). The IL-6 receptor is present in a membrane-bound form that penetrates and is expressed on the cell membrane, and also as a soluble IL-6 receptor, which mainly consists of the extracellular region of the membrane-bound form.

The other kind of protein is the membrane protein gp130, which has a molecular weight of about 130 kDa and is involved in non-ligand binding signal transduction. The biological activity of IL-6 is transmitted into the cell through formation of an IL-6/IL-6 receptor complex from IL-6 and IL-6 receptor followed by binding of the complex with gp130 (Non-patent Document 7).

IL-6 inhibitors are substances that inhibit the transmission of IL-6 biological activity. Currently, known IL-6 inhibitors include antibodies against IL-6 (anti-IL-6 antibodies), antibodies against IL-6 receptor (anti-IL-6 receptor antibodies), antibodies against gp130 (anti-gp130 antibodies), IL-6 variants, partial peptides of IL-6 or IL-6 receptor, and such.

There are several reports regarding anti-IL-6 receptor antibodies (Non-patent Documents 8 and 9, Patent Documents 1 to 3). One such report details a humanized PM-1 antibody, which is obtained by grafting the complementarity determining region (CDR) of mouse antibody PM-1 (Non-patent Document 10), which is an anti-IL-6 receptor antibody, into a human antibody (Patent Document 4).

Antibodies against IL-6 receptor are used for treatment of inflammatory diseases such as rheumatism. However, inflammatory cytokines including IL-6 form a complex network, and hence it has been unclear whether IL-6 receptor inhibitors are effective for treatment of other diseases such as graft-versus-host disease.

In fact, it has been reported that no therapeutic effect was obtained in IL-6-expressing GVHD model mice even when administered with anti-IL-6 antibody (Non-patent Document 11).

Prior-art documents relevant to the present invention will be shown below.
[0014] Detailed roles of IL-6 receptor in GVHD have remained unclear. Also, it has not been clarified as to what effect on GVHD is produced by administration of IL-6 receptor inhibitors.

[0015] The present invention has been conducted under the circumstances described above. The object of the present invention is to provide novel therapeutic agents for GVHD.

MEANS FOR SOLVING THE PROBLEMS

[0016] As a result of extensive and intensive efforts made to achieve the above object, the inventors of the present invention have found that anti-IL-6 receptor antibody produces a remarkable therapeutic effect in GVHD model mice. This finding led to the completion of the present invention.

[0017] Namely, the present invention more specifically provides [1] to [5] shown below.

[1] A therapeutic agent for graft-versus-host disease (GVHD), which comprises an interleukin 6 (IL-6) receptor inhibitor as an active ingredient.
[2] The therapeutic agent for GVHD according to [1] above, wherein the IL-6 receptor inhibitor is a human IL-6 receptor inhibitor.
[3] The therapeutic agent for GVHD according to [1] above, wherein the IL-6 receptor inhibitor is an anti-IL-6 receptor antibody.
[4] The therapeutic agent for GVHD according to [3] above, wherein the anti-IL-6 receptor antibody is a chimeric antibody, a humanized antibody or a human antibody.
sitting antigen to carry out immunization by a conventional immunization method, fusing the obtained immune cells with a known parent cell using a conventional cell fusion method, and screening for monoclonal antibody-producing cells using a conventional screening method.

More specifically, anti-IL-6 receptor antibodies can be produced as follows: For example, human IL-6 receptor or mouse IL-6 receptor for use as a sensitizing antigen for obtaining antibodies can be obtained by using the IL-6 receptor genes and/or amino acid sequences disclosed in European Patent Publication No. EP 325474 and JP 3-155795 A, respectively.

There are two kinds of IL-6 receptor proteins: one expressed on the cell membrane and the other separated from the cell membrane (soluble IL-6 receptor) (Yasukawa, K. et al., J. Biochem. (1990) 108, 673-676). The soluble IL-6 receptor essentially consists of the extracellular region of the cell membrane-bound IL-6 receptor, and differs from the membrane-bound IL-6 receptor in that it lacks the transmembrane region or both the transmembrane and intracellular regions. Any IL-6 receptor may be employed as an IL-6 receptor protein, so long as it can be used as a sensitizing antigen for producing anti-IL-6 receptor antibody used in the present invention.

After transforming an appropriate host cell with a known expression vector system inserted with an IL-6 receptor gene sequence, the desired IL-6 receptor protein is purified from the inside of the host cell or from the culture supernatant using a known method. This purified IL-6 receptor protein may be used as a sensitizing antigen. Alternatively, a cell expressing IL-6 receptor or a fusion protein between IL-6 receptor protein and another protein may be used as a sensitizing antigen.

Mammals to be immunized with a sensitizing antigen are not particularly limited, but are preferably selected in consideration of compatibility with the parent cell used for cell fusion. Generally, rodents such as mice, rats, and hamsters are used.

Animals are immunized with a sensitizing antigen according to known methods. For example, as a general method, animals are immunized by intraperitoneal or subcutaneous injection of a sensitizing antigen. Specifically, the sensitizing antigen is preferably diluted or suspended in an appropriate amount of phosphate-buffered saline (PBS), physiological saline or such and, if desired, further mixed and emulsified with an appropriate amount of a commonly used adjuvant (e.g., Freund’s complete adjuvant), and then administered to a mammal several times, every four to 21 days. In addition, an appropriate carrier may be used for immunization with a sensitizing antigen.

Following such immunization, an increased level of a desired antibody in serum is confirmed and then immune cells are obtained from the mammal for cell fusion. Preferred immune cells for cell fusion include, in particular, spleen cells.


Basically, cell fusion of the aforementioned immune cells and myeloma cells can be performed using known methods, for example, the method of Milstein et al. (Kohler, G. and Milstein, C., Methods Enzymol. (1981) 73, 3-46), and such.

More specifically, the aforementioned cell fusion is achieved in standard nutrient culture medium in the presence of a cell fusion enhancing agent. For example, polyethylene glycol (PEG), Sendai virus (HVJ), and such are used as fusion enhancing agents. Further, to enhance fusion efficiency, auxiliary agents such as dimethyl sulfoxide may be added depending on needs.

The ratio of immune cells to myeloma cells used is preferably, for example, 1:10 immune cells for each myeloma cell. The culture medium used for the aforementioned cell fusion is, for example, RPMI1640 or MEM culture medium, which is suitable for proliferation of the aforementioned myeloma cells. A standard culture medium used for culturing this type of cell can also be used. Furthermore, serum supplements such as fetal calf serum (FCS) can be used in combination.

For cell fusion, the fusion cells (hybridomas) of interest are formed by well mixing predetermined amounts of an aforementioned immune cell and myeloma cell in an aforementioned culture medium, and then adding and mixing a PEG solution (e.g., a PEG solution with a mean molecular weight of about 1,000 to 6,000) pre-heated to about 37°C at a concentration of 30% to 60% (w/v). Then, cell fusion agents and such that are unsuitable for the growth of hybridomas can be removed by repeatedly adding an appropriate culture medium and then removing the supernatant by centrifugation.

The above hybridomas are selected by being cultured in a standard selection culture medium, for example, HAT culture medium (a culture medium containing hypoxanthine, aminopterin, and thymidine). Culture in HAT culture medium is continued for a sufficient period, generally several days to several weeks, to kill cells other than the hybridomas of interest (unfused cells). Then, a standard limited dilution method is performed to screen and clone hybridomas that produce an antibody of interest.

In addition to the methods for immunizing non-human animals with antigens for obtaining the aforementioned hybridomas, desired human antibodies with the activity of binding to a desired antigen or antigen-ex-
pressing cell can be obtained by sensitizing a human lymphocyte with a desired antigen protein or antigen-expressing cell in vitro, and fusing the sensitized B lymphocyte with a human myeloma cell (e.g., U266) (see, JP 1-59878 B). Further, a desired human antibody can be obtained by administering an antigen or antigen-expressing cell to a transgenic animal that has a repertoire of human antibody genes, and then following the aforementioned method (see, International Patent Publication Nos. WO 93/12227, WO 92/03918, WO 94/02602, WO 94/25585, WO 96/34096, and WO 96/33735).

[0038] The thus prepared hybridomas which produce monoclonal antibodies can be subcultured in a conventional culture medium and stored in liquid nitrogen for a long period.

[0039] When obtaining monoclonal antibodies from the aforementioned hybridomas, the following methods may be employed: a method where the hybridomas are cultured according to conventional methods and the antibodies are obtained as a culture supernatant; a method where the hybridomas are administered to and proliferated in a compatible mammal and the antibodies are obtained as ascites; and so on. The former method is preferred for obtaining antibodies with high purity, and the latter is preferred for large-scale antibody production.

[0040] For example, anti-IL-6 receptor antibody-producing hybridomas can be prepared by the method disclosed in JP 3-139293 A. Such hybridomas can be prepared by injecting a PM-1 antibody-producing hybridoma into the abdominal cavity of a BALB/c mouse, obtaining ascites, and then purifying PM-1 antibody from the ascites; or by culturing the hybridoma in an appropriate medium (e.g., RPMI1640 medium containing 10% fetal bovine serum and 5% BM-Condimed H1 (Boehringer Mannheim); hybridoma SFM medium (GIBCO-BRL); PFHM-II medium (GIBCO-BRL), etc.) and then obtaining PM-1 antibody from the culture supernatant.

[0041] Recombinant antibodies can be used as the monoclonal antibodies of the present invention, wherein the antibodies are produced using genetic recombination techniques by cloning an antibody gene from a hybridoma, inserting the gene into an appropriate vector, and then introducing the vector into a host (see, for example, Borrebaeck, C. A. K. and Larrick, J. W., Therapeutic Monoclonal Antibodies, published in the United Kingdom by Macmillan Publishers Ltd, 1990).

[0042] More specifically, mRNAs encoding antibody variable (V) regions are isolated from cells that produce antibodies of interest, such as hybridomas. mRNAs can be isolated by preparing total RNAs according to known methods, such as the guanidine ultracentrifugation method (Chirgwin, J. M. et al., Biochemistry (1979) 18, 5294-5299) and the AGPC method (Chomczynski, P. et al., Anal. Biochem. (1987) 162, 156-159), and preparing mRNAs using a mRNA Purification Kit (Pharmacia) and such. Alternatively, mRNAs can be directly prepared using a QuickPrep mRNA Purification Kit (Pharmacia).

[0043] cDNAs of the antibody V regions are synthesized from the obtained mRNAs using reverse transcriptase. cDNAs may be synthesized using an AMV Reverse Transcriptase First-strand cDNA Synthesis Kit and so on. Further, to synthesize and amplify the cDNAs, the 5’-RACE method (Frohman, M. A. et al., Proc. Natl. Acad. Sci. USA (1988) 85, 8998-9002; Belyavsky, A. et al., Nucleic Acids Res. (1989) 17, 2919-2932) using a 5’-Ampli FINDER RACE Kit (Clontech) and PCR may be employed. A DNA fragment of interest is purified from the obtained PCR products and then ligated with vector DNA. Then, a recombinant vector is prepared using the above DNA and introduced into Escherichia coli or such, and then its colonies are selected to prepare a desired recombinant vector. The nucleotide sequence of the DNA of interest is confirmed by a known method, for example, the dideoxy method.

[0044] Once DNA encoding the V region of an antibody of interest has been obtained, the DNA is ligated with DNA that encodes a desired antibody constant region (C region), and inserted into an expression vector. Alternatively, DNA encoding an antibody V region may be inserted into an expression vector comprising DNA of an antibody C region.

[0045] To produce an antibody to be used in the present invention, as described below, an antibody gene is inserted into an expression vector such that it is expressed under the control of an expression regulating region, for example, an enhancer and promoter. Then, the antibody can be expressed by transforming a host cell with this expression vector.

[0046] In the present invention, to reduce heteroantigenicity against humans and such, artificially modified recombinant antibodies, for example, chimeric antibodies or humanized antibodies, can be used. These modified antibodies can be prepared using known methods.

[0047] A chimeric antibody can be obtained by ligating DNA encoding an antibody V region, obtained as above, with DNA encoding a human antibody C region, then inserting the DNA into an expression vector and introducing it into a host for production (see, European Patent Publication No. EP 125023; International Patent Publication No. WO 92/19759).

This known method can be used to obtain chimeric antibodies useful for the present invention.

[0048] Humanized antibodies are also referred to as reshaped human antibodies, and are antibodies wherein the complementarity determining regions (CDRs) of an antibody from a non-human mammal (e.g., a mouse antibody) are grafted into the CDRs of human antibodies. General methods for this gene recombination are also known (see, European Patent Publication No. EP 125023, International Patent Publication No. WO 92/19759).

[0049] More specifically, DNA sequences designed such that the CDRs of a mouse antibody are ligated with the framework regions (FRs) of a human antibody are synthesized by PCR from several oligonucleotides pro-
duced to contain overlapping portions at their termini. The obtained DNA is ligated with human antibody C region-encoding DNA and then inserted into an expression vector. The expression vector is introduced into a host to produce the humanized antibody (see, European Patent Publication No. EP 239400, International Patent Publication No. WO 92/19759).

[0050] The human antibody FRs to be ligated via the CDRs are selected so that the CDRs form suitable antigen binding sites. Amino acid(s) within the FRs of the antibody variable regions may be substituted as necessary so that the CDRs of the reshaped human antibody form appropriate antigen binding sites (Sato, K. et al., Cancer Res. (1993) 53, 851-856).

[0051] Human antibody C regions are generally used for chimeric and humanized antibodies. Examples of human antibody heavy chain C regions include Cγ1, Cγ2, Cγ3 or Cγ4; and for example, Cγ1, Cδ2, Cε3 or Cε4 may be used. Examples of human antibody light chain C regions include κ or λ. Furthermore, to improve the stability of the antibodies or their production, the human antibody C regions may be modified.

[0052] Chimeric antibodies consist of the variable regions of an antibody derived from a non-human mammal and the constant regions of an antibody derived from a human; humanized antibodies consist of the CDRs of an antibody derived from a non-human mammal and the framework regions and constant regions derived from a human antibody. These have reduced antigenicity in the human body, and are thus useful as antibodies for use in the present invention.

[0053] Preferred specific examples of humanized antibodies for use in the present invention include humanized PM-1 antibody (tocilizumab; see, International Patent Publication No. WO 92/19759). Alternatively, modified forms of the humanized PM-1 antibody are also possible, which are designed to comprise substitutions, deletions, additions or other modifications in the amino acid sequence of the humanized PM-1 antibody.

[0054] Furthermore, in addition to the aforementioned methods for obtaining human antibodies, techniques for obtaining human antibodies by panning using a human antibody library are also known. For example, the variable regions of human antibodies can be expressed on phage surfaces as single chain antibodies (scFv) by using the phage display method to thereby select antigen-binding phages. By analyzing the genes of the selected phages, DNA sequences encoding the human antibody variable regions that bind to the antigen can be determined. Once the DNA sequence of scFv that binds to the antigen is revealed, an appropriate expression vector comprising the sequence can be constructed to obtain a human antibody. These methods are already known, and the publications of WO 92/01047, WO 92/20791, WO93/06213, WO 93/11236, WO 93/19172, WO 95/01438, and WO 95/15388 can be used as reference.

[0055] The antibody genes constructed above can be expressed according to conventional methods. When a mammalian cell is used, the antibody gene can be expressed using DNA in which the antibody gene to be expressed is operably linked to a useful commonly used promoter and a poly A signal downstream of the antibody gene, or using a vector comprising the DNA. Examples of a promoter/enhancer include the human cytomegalovirus immediate early promoter/enhancer.

[0056] Furthermore, other promoters/enhancers that can be used for expressing the antibodies for use in the present invention include viral promoters/enhancers from retrovirus, polyoma virus, adeno virus, simian virus 40 (SV40), and such; and also include mammalian cell-derived promoters/enhancers such as human elongation factor 1α (HEF1α).

[0057] For example, when the SV40 promoter/enhancer is used, the expression can be easily performed according to the method of Mulligan et al. (Mulligan, R. C. et al., Nature (1979) 277, 108-114). Alternatively, in the case of using the HEF1α promoter/enhancer, the method of Mizushima et al. (Mizushima, S. and Nagata S., Nucl. Acids Res. (1990) 18, 5322) can be used.

[0058] Production systems using prokaryotic host cells include those using bacterial cells. Known bacterial cells include E. coli and Bacillus subtilis.

[0059] When E. coli is used, an antibody gene can be expressed by operably liking a conventional useful promoter, a signal sequence for antibody secretion, and the antibody gene to be expressed. Examples of such a promoter include lacZ promoter, araB promoter and such. When the lacZ promoter is used, genes can be expressed according to the method of Ward et al. (Ward, E. S. et al., Nature (1989) 341, 544-546; Ward, E. S. et al., FASEB J. (1992) 6, 2422-2427); and the araB promoter may be used according to the method of Better et al. (Better, M. et al., Science (1988) 240, 1041-1043).

[0060] When the antibody is produced into the periplasm of E. coli, the pel B signal sequence (Lei, S. P. et al., J. Bacteriol. (1987) 169, 4379-4383) may be used as a signal sequence for antibody secretion. The antibodies produced into the periplasm are isolated and appropriately refolded before use (see, for example, WO 98/30394).

[0061] As the replication origin, those derived from SV40, polyoma virus, adeno virus, bovine papilloma virus (BPV) and such may be used. In addition, to enhance the gene copy number in a host cell system, the expression vector may comprise the aminoglycoside phosphotransferase (APH) gene, thymidine kinase (TK) gene, E. coli xanthine-guanine phosphoribosyltransferase (EC-gpt) gene, dihydrofolate reductase (dhfr) gene, or such as a selection marker.

[0062] Any production system may be used to prepare the antibodies for use in the present invention. The production systems for antibody preparation include in vitro and in vivo production systems. In vitro production systems include those using eukaryotic cells or prokaryotic cells.

[0063] Production systems using eukaryotic host cells
include those using animal cells, plant cells, or fungal cells. Such animal cells include (1) mammalian cells, for example, CHO, COS, myeloma, baby hamster kidney (BHK), HeLa, Vero, and such; (2) amphibian cells, for example, *Xenopus* oocyte; and (3) insect cells, for example, sf9, sf21, Tn5, and such. Known plant cells include those derived from *Nicotiana tabacum*, which may be cultured as a callus. Known fungal cells include yeasts such as *Saccharomyces* (e.g., *S. cerevisiae*), mold fungi such as *Aspergillus* (e.g., *A. niger*), and such.

**[0064]** Antibodies can be obtained by using transformation to introduce an antibody gene of interest into these cells, and then culturing the transformed cells *in vitro*. Cultures are conducted according to known methods. For example, DMEM, MEM, RPMI1640, IMDM may be used as the culture medium, and serum supplements such as FCS may be used in combination. Further, the cells introduced with the antibody gene may be transferred into the abdominal cavity or such of an animal to produce the antibodies *in vivo*.

**[0065]** On the other hand, *in vivo* production systems include those using animals or plants. Production systems using animals include those that use mammals or insects.

**[0066]** Mammals that can be used include goats, pigs, sheep, mice, bovines and such (Vicki Glaser, SPECTRUM Biotechnology Applications, 1993). Further, insects that can be used include silkworms. When using plants, tobacco may be used, for example.

**[0067]** An antibody gene is introduced into these animals or plants, and the antibody is produced in the body of the animals or plants and then recovered. For example, an antibody gene can be prepared as a fusion gene by being inserted into the middle of a gene encoding a protein such as goat β casein, which is uniquely produced into milk. DNA fragments comprising the fusion gene, which includes the antibody gene, are injected into goat embryos, and the embryos are introduced into female goats. The desired antibody is obtained from milk produced by the transgenic animals born to the goats that received the embryos, or produced from progenies of these animals. The transgenic goats can be given hormones to increase the volume of milk containing the desired antibody that they produce (Ebert, K. M. et al., Bio/Technology (1994) 12, 699-702).

**[0068]** When silkworms are used, the silkworms are infected with baculovirus inserted with a desired antibody gene, and the desired antibody is obtained from the body fluids of these silkworms (Maeda, S. et al., Nature (1985) 315, 592-594). Moreover, when tobacco is used, a desired antibody gene is inserted into a plant expression vector (e.g., pMON530) and the vector is introduced into bacterial cells such as *Agrobacterium tumefaciens*. These bacterial cells are used to infect tobacco (e.g., *Nicotiana tabacum*) such that desired antibodies can be obtained from the leaves of this tobacco (Julian, K. -C. Ma et al., Eur. J. Immunol. (1994) 24, 131-138).

**[0069]** When producing antibodies using *in vitro* or *in vivo* production systems, as described above, DNA encoding an antibody heavy chain (H chain) and light chain (L chain) may be inserted into separate expression vectors and co-transformed into a host. Alternatively, DNAs encoding the H and L chains may be inserted into a single expression vector for transforming a host (see International Patent Publication No. WO 94/11523).

**[0070]** The antibodies used in the present invention may be antibody fragments or modified products thereof, so long as they can be suitably used in the present invention. For example, antibody fragments include Fab, F(ab′)2, Fv, and single chain Fv (scFv), in which the Fvs of the H and L chains are linked via an appropriate linker.


**[0072]** scFv can be obtained by linking the H-chain V region and the L-chain V region of an antibody. In the scFv, the H-chain V region and the L-chain V region are linked via a linker, preferably via a peptide linker (Huston, J. S. et al., Proc. Natl. Acad. Sci. USA (1988) 85, 5879-5883). The V regions of the and L chains in scFv may be derived from any of the antibodies described above. Peptide linkers for linking the V regions include, for example, arbitrary single chain peptides consisting of 12 to 19 amino acid residues.

**[0073]** scFv-encoding DNA can be obtained by using DNA encoding the above antibody H chain or H-chain V region and DNA encoding the above antibody L chain or L-chain V region as templates in PCR to amplify a DNA portion that encodes a desired amino acid sequence in the template sequence with primers that define the termini of the portion, and then further amplifying the amplified DNA portion with DNA that encodes a peptide linker portion and primer pairs that link both ends of the linker to the H and L chains, respectively.

**[0074]** Once scFv-encoding DNA has been obtained, an expression vector comprising the DNA and a host transformed with the vector can be obtained according to conventional methods. In addition, scFv can be obtained according to conventional methods using the host.

**[0075]** These antibody fragments can be produced from hosts by obtaining and expressing their genes, as described above. Herein, the term “antibody” encompasses such antibody fragments.

**[0076]** Antibodies bound to various molecules, such as polyethylene glycol (PEG), may also be used as modified antibodies. Herein, the term “antibody” encompasses such modified antibodies. These modified antibodies
can be obtained by chemically modifying the obtained antibodies. Such methods are already established in the art. [0077] Antibodies produced and expressed as above can be isolated from the inside or outside of the cells or from the hosts, and then purified to homogeneity. The antibodies for use in the present invention can be isolated and/or purified using affinity chromatography. Columns to be used for affinity chromatography include, for example, protein A columns and protein G columns. Carriers used for protein A columns include, for example, HyperD, POROS, Sepharose FF and such. In addition to the above, other methods commonly used for isolation and/or purification of proteins may be used, and are not limited in any way. [0078] For example, the antibodies used in the present invention may be isolated and/or purified by appropriately selecting and combining chromatographies in addition to affinity chromatography, filters, ultrafiltration, salting-out, dialysis, and such. Chromatographies include, for example, ion-exchange chromatography, hydrophobic chromatography, gel filtration, and such. These chromatographies can be applied to high performance liquid chromatography (HPLC). Alternatively, reverse phase HPLC may be used. [0079] The concentration of the antibodies obtained as above can be determined by absorbance measurement, ELISA, or such. Specifically, absorbance is determined by appropriately diluting the antibody solution with PBS(-), measuring the absorbance at 280 nm, and calculating the concentration (1.35 OD = 1 mg/ml). Alternatively, when using ELISA, the measurement can be performed as follows: Specifically, goat anti-human IgG (TAG) diluted to 1 μg/ml with 0.1 M bicarbonate buffer (pH 9.6) is added at 100 μl per well in a 96-well plate (Nunc) and incubated overnight at 4°C to immobilize the antibody. After washing, an appropriately diluted antibody of the present invention or an appropriately diluted sample comprising the antibody, or human IgG (CAP- PEL) as a standard is added in 100 μl volumes and incubated for one hour at room temperature. [0080] After washing, 5,000x diluted alkaline phosphatase-labeled anti-human IgG (BIO SOURCE) is added in 100 μl volumes and incubated for one hour at room temperature. After another wash, a substrate solution is added and incubated, and the absorbance at 405 nm is measured using a Microplate Reader Model 3550 (Bi- Rad) to calculate the concentration of the antibody of interest. [0081] Partial peptides of IL-6 receptor are peptides that comprise part or all of the amino acid sequence of the region of the IL-6 receptor amino acid sequence that is involved in the binding between IL-6 and IL-6 receptor. Such peptides usually comprise 10 to 80, preferably 20 to 50, more preferably 20 to 40 amino acid residues. [0082] IL-6 receptor partial peptides can be produced according to generally known methods, for example, genetic engineering techniques or peptide synthesis methods, by specifying the region of the IL-6 receptor amino acid sequence that is involved in the binding between IL-6 and IL-6 receptor, and using a portion or entirety of the amino acid sequence of the specified region. [0083] When preparing an IL-6 receptor partial peptide using genetic engineering methods, a DNA sequence encoding the desired peptide is inserted into an expression vector, and then the peptide can be obtained by applying the aforementioned methods for expressing, producing and purifying recombinant antibodies. [0084] When producing an IL-6 receptor partial peptide by using peptide synthesis methods, generally used peptide synthesis methods, for example, solid phase synthesis methods or liquid phase synthesis methods, may be used. [0085] Specifically, the peptides can be synthesized according to the method described in "Continuation of Development of Pharmaceuticals, Vol. 14, Peptide Syn- thesis (in Japanese)" (ed. Haruaki Yajima, 1991, Hi- rokawa Shoten). As a solid phase synthesis method, for example, the following method can be employed: the amino acid corresponding to the C terminus of the peptide to be synthesized is bound to a support that is insoluble in organic solvents, then the peptide strand is elongated by alternately repeating (1) the reaction of condensing amino acids, whose α-amino groups and branch chain functional groups are protected with appropriate protecting groups, one at a time in a C- N-terminal direction; and (2) the reaction of removing the protecting groups from the α-amino groups of the resin-bound amino acids or peptides. Solid phase peptide synthesis is broadly classified into the Boc method and the Fmoc method, depending on the type of protecting groups used. [0086] After synthesizing a peptide of interest as above, deprotection reactions are carried out, then the peptide strand is cleaved from its support. For the cleavage reaction of the peptide strand, hydrogen fluoride or trifluoromethane sulfonic acid is generally used in the Boc method, and TFA is generally used in the Fmoc method. In the Boc method, for example, the above-mentioned protected peptide resin is treated with hydrogen fluoride in the presence of anisole. Then, the peptide is recovered by removing the protecting groups and cleav- ing the peptide from its support. By freeze-drying the re- covered peptide, a crude peptide can be obtained. In the Fmoc method, on the other hand, the deprotection reac- tion and the reaction to cleave the peptide strand from the support can be performed in TFA using a method similar to those described above, for example. [0087] Obtained crude peptides can be separated and/or purified by being applied to HPLC. Elution may be performed under optimum conditions using a water-acetonitrile solvent system, which is generally used for protein purification. Fractions corresponding to the peaks of the obtained chromatographic profile are collected and freeze-dried. The peptide fractions thus purified are identi- fied by molecular weight analysis via mass spectrome- try, amino acid composition analysis, amino acid se-
sequence analysis, or such.

[0088] The therapeutic agents for GVHD of the present invention can be used in treating and/or preventing GVHD. The therapeutic agents for GVHD of the present invention also include prophylactic agents for GVHD which suppress the development of GVHD. Thus, the phrase "therapeutic (agent) for GVHD" as used herein is intended to mean suppressing GVHD, reducing the occurrence of GVHD, treating GVHD, ameliorating the symptoms of GVHD, etc.

[0089] Any type of GVHD can be treated by the therapeutic agents of the present invention. GVHD, that can be treated by the therapeutic agents of the present invention includes acute GVHD and chronic GVHD. The therapeutic agents for GVHD of the present invention are particularly effective against GVHD following hematopoietic stem cell transplantation, such as GVHD following peripheral blood stem cell transplantation (e.g., allogeneic peripheral blood stem cell transplantation) or GVHD following bone marrow transplantation (e.g., allogeneic bone marrow transplantation).

[0090] IL-6 receptor inhibitors used in the present invention can be evaluated for their effect as therapeutic agents for GVHD, for example but not limited to, by using their inhibitory activity against signal transduction as an index. The inhibitory activity of IL-6 receptor inhibitors against signal transduction can be evaluated by conventional methods. Specifically, IL-6 is added to cultures of IL-6-dependent human myeloma cell lines (S6B45 and KPMM2), human Lennert T lymphoma cell line KT3, or IL-6-dependent cell line MH60.BSF2; and the 3H-thymidine uptake by the IL-6-dependent cells is measured in the presence of an IL-6 receptor inhibitor. Alternatively, IL-6 receptor-expressing U266 cells are cultured, and 125I-labeled IL-6 and an IL-6 receptor inhibitor are added to the culture at the same time; and then 125I-labeled IL-6 bound to the IL-6 receptor-expressing cells is quantified. In addition to the IL-6 receptor inhibitor group, a negative control group that contains no IL-6 receptor inhibitor is included in the assay system described above. The activity of the IL-6 receptor inhibitor to inhibit IL-6 receptor can be evaluated by comparing the results of both groups.

[0091] Subjects to be administered with the therapeutic agents for GVHD of the present invention are mammals. The mammals are preferably humans.

[0092] The therapeutic agents for GVHD of the present invention can be administered as pharmaceuticals, and may be administered systemically or locally via oral or parenteral administration. For example, intravenous injections such as drip infusions, intramuscular injections, intraperitoneal injections, subcutaneous injections, suppositories, enemas, oral enteric tablets, or the like can be selected. Appropriate administration methods can be selected depending on a patient's age and symptoms. The effective dose per administration is not limited in any way, but is selected from the range of 0.01 to 100 mg/kg body weight. Alternatively, the dose may be selected from the range of 1 to 1000 mg/patient, preferably from the range of 5 to 50 mg/patient. By way of specific example, a preferred dose and administration method are as follows: For example, when anti-IL-6-receptor antibody is used, a dose of 0.5 to 40 mg/kg body weight/month (four weeks), preferably 1 to 20 mg/kg body weight/month is administered via an intravenous injection such as a drip infusion, subcutaneous injection, intramuscular injection or such, once to several times a month, for example, twice a week, once a week, once every two weeks, or once every four weeks. The administration schedule may be adjusted by, for example, extending the administration interval of twice a week or once a week to once every two weeks, once every three weeks, or once every four weeks, while monitoring the patient's condition and changes in the blood test values.

[0093] As described later in the Example section, the therapeutic agents for GVHD of the present invention were able to remarkably suppress the development of GVHD when administered to recipients before and after hematopoietic stem cell transplantation. Thus, the therapeutic agents for GVHD of the present invention are preferably administered before hematopoietic stem cell transplantation and further administered after the transplantation depending on the condition of GVHD.

[0094] The therapeutic agents for GVHD of the present invention may be administered in combination with at least one known therapeutic agent or method for GVHD. For example, the therapeutic agents of the present invention may be administered simultaneously or sequentially with an immunosuppressive agent(s) (e.g., cyclosporin, tacrolimus, methotrexate) used for prevention of GVHD. Moreover, the therapeutic agents of the present invention may be combined with removal of mature T cells from a group of transplant cells (graft).

[0095] The therapeutic agents for GVHD of the present invention may contain pharmaceutically acceptable carriers, such as preservatives and stabilizers. "Pharmacologically acceptable carriers" refer to materials that can be co-administered with the above agents. Such pharmaceutically acceptable materials include, for example, sterile water, physiological saline, stabilizers, excipients, buffers, preservatives, detergents, chelating agents (e.g., EDTA), and binders.

[0096] In the present invention, detergents include non-ionic detergents, and typical examples of such include sorbitan fatty acid esters such as sorbitan monopalmitate, sorbitan monolaurate, and sorbitan monopalmitate; glycercin fatty acid esters such as glycerin monopalmitate, glycerin monostearate and glycerin monoooleate; polyglycerin fatty acid esters such as decaglyceril monostearate, decaglyceril distearate, and decaglyceril monolinoleate; polyoxyethylene sorbitan fatty acid esters such as polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan monoooleate, polyoxyethylene sorbitan tristearate; polyoxyethylene sorbit
fatty acid esters such as polyoxyethylene sorbit tetra-
steareate and polyoxyethylene sorbit tetaoleate; polyox-
yethylene glycerin fatty acid esters such as polyoxyeth-
ylene glycerol monostearate; polyethylene glycol fatty acid esters such as polyethylene glycol distearate; poly-
oxylene glycol ethers such as polyethylene lauryl ether; polyoxyethylene polyoxypropylene alkyl ethers such as polyoxyethylene polyoxypropylene glycol, poly-
oxylene polyoxypropylene propyl ether, and polyox-
yethylene polyoxypropylene cetyl ether; polyoxyethylene hardened castor oils such as polyoxyethylene castor oil and polyoxyethylene hardened castor oil (polyoxyethylene hydrogenated castor oil); polyoxyethylene beeswax surfactants such as polyoxy-
yethylene lanolin and polyoxyethylene lanolin derivatives such as polyoxyethylene lanolin; and polyoxy-
yethylene fatty acid amides and such with an HLB of 6 to 18, such as polyoxyethylene stearylfatty acid amide.

[0097] Detergents also include anionic detergents, and typical examples of such include, for example, alkyl sulfates having an alkyl group with 10 to 18 carbon atoms, such as sodium cetyl sulfate, sodium lauryl sulfate, and sodium oleyl sulfate; polyoxyethylene alkyl ether sulfates in which the alkyl group has 10 to 18 carbon atoms and the average molar number of added ethylene oxide is 2 to 4, such as sodium polyoxyethylene laurel sulfate; alkyl sulfosuccinate esters having an alkyl group with 8 to 18 carbon atoms, such as sodium laurel sulfosuccinate ester; natural detergents, for example, lecithin; glycerophospholipids; sphingo-phospholipids; surfactin; and sucrose fatty acid esters in which the fatty acids have 12 to 18 carbon atoms.

[0098] One or more of the detergents described above can be combined and added to the agents of the present invention. Detergents that are preferably used in the preparations of the present invention include polyoxyethylene sorbitan fatty acid esters, such as polysorbates 20, 40, 60 and 80. Polysorbates 20 and 80 are particularly preferred. Polyoxyethylene polyoxypropylene glycols, such as poloxamer (e.g., Pluronic F-68<sup>®</sup>), are also preferred.

[0099] The amount of detergent added varies depending on the type of detergent used. When polysorbate 20 or 80 is used, the amount is in general in the range of 0.001 to 100 mg/ml, preferably in the range of 0.003 to 50 mg/ml, more preferably in the range of 0.005 to 2 mg/ml.

[0100] In the present invention, buffers include phosphate or citrate buffer, acetic acid, malic acid, tartaric acid, succinic acid, lactic acid, potassium phosphate, glu-
conic acid, capric acid, deoxycholic acid, salicylic acid, triethanolamine, fumaric acid, and other organic acids; as well as carbonate buffer, Tris buffer, histidine buffer, and imidazole buffer.

[0101] Liquid preparations may be formulated by dis-
solving the agents in aqueous buffers known in the field of liquid preparations. The buffer concentration is in gen-
eral in the range of 1 to 500 mM, preferably in the range of 5 to 100 mM, more preferably in the range of 10 to 20 mM.

[0102] The therapeutic agents of the present invention may also comprise other low-molecular-weight polypeptides; proteins such as serum albumin, gelatin, and immu-

[0103] Herein, amino acids include basic amino acids, for example, arginine, lysine, histidine, and ornithine, and inorganic salts of these amino acids (preferably hydro-
chloride salts, and phosphate salts, namely phosphate amino acids). When free amino acids are used, the pH is adjusted to a preferred value by adding appropriate physiologically acceptable buffering substances, for example, inorganic acids, in particular hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, and fomic acid, and salts thereof. In this case, the use of phosphate is particularly beneficial because it gives quite stable freeze-dried products. Phosphate is particularly advan-
tageous when preparations do not substantially contain organic acids, such as malic acid, tartaric acid, citric acid, succinic acid, and fumaric acid, or do not contain corre-
sponding anions (e.g., malate ion, tartrate ion, citrate ion, succinate ion, fumarate ion). Preferred amino acids are arginine, lysine, histidine, and ornithine. It is also possible to use acidic amino acids such as glutamic acid and as-
partic acid, and salts thereof (preferably sodium salts); neutral amino acids such as isoleucine, leucine, glycine, serine, threonine, valine, methionine, cysteine, and alanine; or aromatic amino acids such as phenylalanine, tyrosine, tryptophan, and its derivative, N-acetyl tryptophan.

[0104] Herein, sugars and carbohydrates such as polysaccharides and monosaccharides include, for example, dextran, glucose, fructose, lactose, xylose, mannose, maltose, sucrose, trehalose, and raffinose.

[0105] Herein, sugar alcohols include, for example, mannitol, sorbitol, and inositol.

[0106] When the agents of the present invention are prepared as aqueous solutions for injection, the agents may be mixed with, for example, physiological saline, and/or isotonic solution containing glucose or other aux-
lary agents (e.g., D-sorbitol, D-mannose, D-mannitol, sodium chloride). The aqueous solutions may be used in combination with appropriate solubilizers such as al-
cohols (e.g., ethanol), polyalcohols (e.g., propylene gly-
ol, PEG), or non-ionic detergents (e.g., polysorbate 80, HCO-50).

[0107] The agents may further comprise, if required, diluents, solubilizers, pH adjusters, soothing agents, sul-
fur-containing reducing agents, antioxidants, and such.

[0108] Herein, the sulfur-containing reducing agents include, for example, compounds comprising sulfhydryl groups, such as N-acetylcysteine, N-acetylhomocysteine, thiolic acid, thioglycolic acid, and salts thereof,
sodium thiosulfate, glutathione, and thioalkanoic acids having 1 to 7 carbon atoms.

Moreover, the antioxidants in the present invention include, for example, erythorbic acid, dibutylhydroxy toluene, butylhydroxy anisole, α-tocopherol, tocopherol acetate, L-ascorbic acid and salts thereof, L-ascorbic acid palmitate, L-ascorbic acid stearate, sodium hydrogen sulfite, sodium sulfite, triamyl gallate, propyl gallate, and chelating agents such as disodium ethylenediamine tetraacetate (EDTA), sodium pyrophosphate, and sodium metaphosphate.


Pharmaceutically acceptable carriers used are appropriately selected from those described above or combined depending on the type of dosage form, but are not limited thereto.

The present invention relates to a method for treating and/or preventing GVHD in a subject, which comprises the step of administering an IL-6 receptor inhibitor to a subject developing GVHD.

Herein, the "subject" refers to an organism or an organism body part to be administered with the therapeutic agents for GVHD of the present invention. Such an organism includes animals (for example, human, domestic animal species, and wild animals) but is not particularly limited.

"Administration" includes oral and parenteral administration. Oral administration includes, for example, administration of oral agents. Such oral agents include, for example, granules, powders, tablets, capsules, solutions, emulsions, and suspensions.

Parenteral administration includes, for example, administration of injections. Such injections include, for example, subcutaneous injections, intramuscular injections, intravenous injections and intraperitoneal injections.

EXAMPLES

Example 1: Effect of IL-6 receptor antibody on GVHD

Test method

Spleen cells (6 × 10⁷ cells/mouse) obtained from female C57BL/6J donor mice at 8 weeks of age (Charles River Japan, Inc.) were transferred to female B6D2F1/Crlj recipient mice at 8 weeks of age (Charles River Japan, Inc.) via the tail vein to induce GVHD.

The recipient mice were divided into two groups, one of which was administered with anti-mouse IL-6 receptor antibody MR16-1 (Chugai Pharmaceutical Co., Ltd., Japan) at 4 mg/mouse via the tail vein at 1 day before spleen cell transfer and then at 0.5 mg/mouse via the intraperitoneal route four times every 7 days. The control group was administered with phosphate-buffered saline (PBS; SIGMA-ALDRICH Inc.) (10 animals for each group). After spleen cell transfer, the mice were measured for their body weight three times a week to evaluate the development of GVHD based on their body weight.

Results

The results obtained are shown in Figure 2. The control group showed a biphasic decrease in the body weight. Namely, the body weight was decreased on days 9 to 14 after spleen cell transplantation and then recovered on day 16, but decreased again on days 19 to 21 and then substantially recovered on day 33. In contrast, the MR16-1-receiving group showed no decrease in the body weight on days 9 to 14. Namely, these results suggest that anti-IL-6 receptor antibody suppresses the development of GVHD.

Claims

1. A therapeutic agent for graft-versus-host disease (GVHD), which comprises an interleukin 6 (IL-6) receptor inhibitor as an active ingredient.

2. The therapeutic agent for GVHD according to claim 1, wherein the IL-6 receptor inhibitor is a human IL-6 receptor inhibitor.

3. The therapeutic agent for GVHD according to claim 1, wherein the IL-6 receptor inhibitor is an anti-IL-6 receptor antibody.
receptor antibody.

4. The therapeutic agent for GVHD according to claim 3, wherein the anti-IL-6 receptor antibody is a chimeric antibody, a humanized antibody or a human antibody.

5. A method for treating graft-versus-host disease (GVHD), which comprises administering a therapeutically effective amount of an interleukin 6 (IL-6) receptor inhibitor.
Figure 1

Body Weight (g)
## INTERNATIONAL SEARCH REPORT

### A. CLASSIFICATION OF SUBJECT MATTER

A61K45/00(2006.01)i, A61K39/395(2006.01)i, A61P37/06(2006.01)i, A61P43/00 (2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61K45/00, A61K39/395, A61P37/06, A61P43/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996
Kokai Jitsuyo Shinan Koho 1971-2008
Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

BIOSIS (STN), Capplus (STN), EMBASE (STN), MEDLINE (STN), JSTPlus (JDreamII), JHEDPlus (JDreamII), JST7580 (JDreamII)

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>

* Further documents are listed in the continuation of Box C.  

* Special categories of cited documents:
  - **A** document defining the general state of the art which is not considered to be of particular relevance
  - **E** earlier application or patent but published on or after the international filing date
  - **L** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - **O** document referring to an oral disclosure, use, exhibition or other means
  - **P** document published prior to the international filing date but later than the priority date claimed

* I later document published after the international filing date or priority date and in conflict with the application but cited to understand the principle or theory underlying the invention

* X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

* Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

* A document member of the same patent family

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Date of the actual completion of the international search  
01 December, 2008 (01.12.08)

Date of mailing of the international search report  
09 December, 2008 (09.12.08)

Name and mailing address of the ISA  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form: PCT/ISA/210 (second sheet) (April 2007)
INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 5
   because they relate to subject matter not required to be searched by this Authority, namely:
   Claim 5 pertains to "a method for treatment of a human body by therapy" and thus relates to a subject matter which this International Searching Authority is not required, under the provisions of PCT Rule 39.1(iv), to search.

2. [ ] Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant’s protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
<Subject of search>

It is recognized that the expressions "an interleukin-6 (IL-6) receptor inhibitor" and "an IL-6 receptor inhibitor" described in functional expression in claims 1 and 2 involve substances over a wide scope such as low-molecular weight compounds, peptides and proteins.

In the description, however, an anti-IL-6 receptor antibody is exclusively confirmed in practice as having a therapeutic effect on GVHD in the meaning within PCT Article 5. No other particular substance is disclosed in the description. Thus, the inventions according to claims 1 and 2 are not sufficiently supported in the meaning within PCT Article 6.

Such being the case, the search was made on the remedy for GVHD comprising, as the active ingredient, the anti-IL-6 receptor antibody of the inventions according to claims 3 and 4 that is disclosed in the description and supported thereby.
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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