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(54) Benævnelse: **MONOKLONALE ANTISTOFFER MOD CLAUDIN-18 TIL CANCERBEHANDLING**

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DESCRIPTION

[0001] Antibody-based therapies for cancer have the potential of higher specificity and lower side effect profile as compared to conventional drugs. The reason is a precise distinction between normal and neoplastic cells by antibodies and the fact, that their mode of action relies on less toxic immunological anti-tumor mechanisms, such as complement activation and recruitment of cytotoxic immune cells.

[0002] Targets for antibody-based therapies need to have particular qualities, which form the basis for proper discrimination between normal and neoplastic cells. Obviously, a target with either exclusive restriction to tumor cells and entirely undetectable on normal tissues is ideal for the development of efficient and safe antibody therapeutics. In another aspect, a high-level overexpression may be the basis for the therapeutic window and low side effects exemplified by the human epidermal growth factor receptor type 2 (HER-2), which as a result of gene amplification is a good target for the antibody trastuzumab (Herceptin).

[0003] Other targets for antibodies which are either already approved or in clinical development for tumor therapy have distinct qualities, which are not based on a numeric overexpression of target molecules on tumor cells. In the case of antibodies to the proteoglycan MUC-1, a peptide repeat epitope in the backbone of the target is underglycosylated in tumor cells and thus altered to its normal counterpart. In the case of antibodies to CD20 (rituximab), CD52 (Campath-1H) and CD22 (epratuzumab), antibody targets have comparable expression levels on tumor cells and normal lymphocytes. Here, the ablation of normal cells by the antibody is tolerable since target-negative stem cells restore the normal lymphocyte repertoire. Other examples of differential accessibility of antibody targets are carcinoembryonal antigen (CEA) and carboanhydrase IX (CA9). Both antigens are expressed on normal epithelia of colon and kidney, respectively. However, radioactively labeled imaging antibodies do distinguish well between tumor and normal tissue, and cytotoxic antibodies are well tolerated. This is most likely due to a restricted expression of CA9 and CEA on the luminal side of normal epithelial tissue where IgG antibodies do not have access. Also antigen epithelial cell adhesion molecule (Ep-CAM) belongs to this category. As a homotypic cell adhesion molecule for epithelial cells it is localized in the intercellular space. Intriguingly, whereas high-affinity anti-Ep-CAM antibodies are very toxic, intermediate-affinity antibodies are well tolerated. This suggests accessibility of the Ep-CAM target on normal cells but also indicates that kinetics of antibody binding may open a therapeutic window.

[0004] One possibility is that other epithelial cell-specific proteins involved in cell/cell adhesion may be also attractive for antibody approaches, since they may be barely accessible in well-structured epithelia to antibodies but become exposed on tumor cells. We therefore analyzed proteins involved in organizing epithelial tissue architecture for their suitability as targets for therapeutic antibodies. A protein, which particularly attracted our attention is claudin 18.

[0005] The claudin 18 (CLD18) molecule (Genbank accession number: splice variant 1 (CLD18A1): NP_057453, NM_016369, and splice variant 2 (CLD18A2): NM_001002026, NP_001002026) is an integral transmembrane protein with a molecular weight of approximately 27,9 / 27,72 kD. Claudins are integral membrane proteins located within the tight junctions of epithelia and endothelia. Tight junctions organize a network of interconnected strands of intramembranous particles between adjacent cells. In tight junctions, occludin and claudins are the most prominent transmembrane protein components. Due to their strong intercellular adhesion properties they create a primary barrier to prevent and control the paracellular transport of solutes and restrict the lateral diffusion of membrane lipids and proteins to maintain cellular polarity. Tight junction forming proteins are critically involved in organizing epithelial tissue architecture. We assumed that such proteins may be barely accessible to antibodies in well-structured epithelia but become exposed on tumor cells.

[0006] CLD18 is a tetraspanin and has as such 4 hydrophobic regions. We have generated data indicating that CLD18 displays several different conformations, which may be selectively addressed by antibodies. One conformation (CLD18-Conformation-1) implies, that all four hydrophobic regions serve as regular transmembrane domains (TM) and two extracellular loops (loop1 embraced by hydrophobic region 1 and hydrophobic region 2;

loop2 embraced by hydrophobic regions 3 and 4) are formed, as described for the vast majority of claudin family members. A second conformation (CLD18-Conformation-2) implies that, as described for PMP22, another member of the tetraspanin family (Taylor et al., J. Neurosc. Res. 62:15-27, 2000), that the second and third hydrophobic domains do not fully cross the plasma membrane so that portion (loopD3) in between the first and fourth transmembrane domain is extracellular. A third conformation (CLD18-Conformation-3) implies, a large extracelluar domain with two internal hydrophobic regions embraced by the first and fourth hydrophobic region, which serve as regular transmembrane domains. Due to the presence of classical N-glycosylation site in loopD3 the Claudin-18 topology variants CLD18 topology-2- and CLD18 topology-3 harbour an additional extracellular N-glycosylation site.

[0007] Another level of complexity is added to CLD18 molecule by the presence of two different splice variants, which are described in mouse and in human (Niimi, Mol. Cell. Biol. 21:7380-90, 2001). The splice variants CLD18A1 and CLD18A2 differ in the first 21 N-terminal amino acids, which comprise the first TM and loop1, whereas the primary protein sequence of the C-terminus is identical.

[0008] CLD18A1 is selectively expressed on normal lung and stomach epithelia, whereas CLD18A2 is expressed only on gastric cells (Niimi, Mol. Cell. Biol. 21:7380-90, 2001). Most importantly, CLD18A2 is restricted to the differentiated short-lived cells of stomach epithelium but is devoid from the gastric stem cell region. Using sensitive RT-PCR, we have shown that both variants are not detectable at all in any other normal human organ, but are robustly expressed in several cancer types including stomach, esophageal, pancreatic and lung tumors as well as human cancer cell lines. In this regard, we refer for example to WO2004/047863 and EP1790664, the former of which also describes monoclonal antibodies binding to CLD18A1 and CLD18A2. Expression is most prominent in the adenocarcinoma subtypes of these indications.

[0009] The molecular weight of the protein differs in some cancers and adjacent normal tissue. The higher molecular weight protein observed in healthy tissue can be transferred into the same molecular weight as observed in cancer by treating tissue lysates with the deglycosylating compound PNGase F. This suggests, that CLD18 is less N-glycosylated in cancer as compared to its normal tissue counterpart. This structural difference is likely to give rise to an altered epitope. A classical N-glycosylation motif is in position aa 116 within the loopD3 domain of the molecule.

[0010] The terms "CLD18" and "CLD18-variant" according to the teaching shall encompass (i) CLD18-splice variants, (ii) CLD18-N-glycosylation variants, (iii) CLD18-conformation variants, (iv) CLD18-free and homotypically/heterotypically associated variants localized at intercellular tight junctions and (v) CLD18-cancer related and CLD18-non-cancer cell related variants.

[0011] The molecular and functional characteristics of CLD18 make this molecule a highly interesting target for antibody based cancer therapy. These are in particular (i) the absence of CLD18 from the vast majority of toxicity relevant normal tissues, (ii) the restriction of CLD18A2 variant expression to a dispensible cell population as differentiated gastric cells, which can be replenished by target-negative stem cells of the stomach, (iii) hints to potential differential glycosylation between normal and neoplastic cells, and (iv) the presence of different conformational topologies. Moreover, the role of CLD18 as tight junction protein may further contribute to a good therapeutic window. Because tumor cells express claudins but often do not form classical tight junctions by homotypic and heterotypic association of claudins as found in normal epithelial tissue, tumor cells may have a considerable pool of free claudin that is amenable to extracellular antibody binding and immunotherapy. It is possible that binding epitopes of claudins in healthy epithelium are shielded within tight junctions from the access by such antibodies.

[0012] Furthermore, the high plasma membrane expression observed according to the teaching not only for primary tumors but also for metastases derived from CLD18A2 expressing primary tumors, in particular, gastric tumors, make CLD18A2 specific antibodies a valuable tool for the prevention, treatment and/or diagnosis of cancer metastasis, in particular metastasis derived from gastric tumors, such as lymph node metastasis, peritoneal metastasis and Krukenberg tumors.

[0013] The object of the teaching is to provide antibodies useful for therapy of diseases wherein CLD18 is expressed, such as tumor diseases. The antibodies described herein have also utility in diagnosing such diseases.

SUMMARY

[0014] The present teaching generally provides antibodies useful as therapeutics for treating and/or preventing diseases associated with cells expressing CLD18, including tumor-related diseases such as gastric cancer, esophageal cancer, pancreatic cancer, lung cancer such as non small cell lung cancer (NSCLC), ovarian cancer, colon cancer, hepatic cancer, head-neck cancer, and cancer of the gallbladder and metastases thereof, in particular gastric cancer metastasis such as Krukenberg tumors, peritoneal metastasis and lymph node metastasis.

[0015] In one aspect the teaching relates to an antibody having the ability of binding to CLD18. Preferably, the antibody has the ability of binding to CLD18 expressed on the cell surface and preferably binds to one or more epitopes located within the extracellular portions of CLD18, preferably within the first extracellular domain (amino acid positions 29 to 78 of CLD18). Preferably, the antibody of the teaching binds to one or more peptides selected from the group consisting of SEQ ID NO: 151, 153, 155, 156 and 157. Preferably, the antibody binds to cancer cells, in particular cells of the cancer types mentioned above and, preferably, does not bind substantially to non-cancerous cells. Preferably, binding of said antibody to cells expressing CLD18 such as cancer cells mediates killing of cells expressing CLD18. Preferably, the antibody binds to CLD18A1 and CLD18A2 and more preferably binds to CLD18A2 but not to CLD18A1. Preferably, antibodies of the teaching bind to and are specific for loop1 or loop2 of CLD-conformation-1. In further preferred embodiments, the antibody of the teaching binds to and is specific for loopD3 of CLD-conformation-2 and, in particular, binds at or around a potential N-glycosylation site at position 116 within loopD3. In further embodiments, the antibody of the teaching is specific for the unglycosylated form of the potential N-glycosylation site at position 116 within loopD3.

[0016] Preferably, binding of antibodies of the teaching to CLD18A2 involves one or more amino acids selected from the group consisting of Ala at position 42, Asn at position 45 and Glu at position 56 of CLD18A2 (SEQ ID NO:2). Preferably, antibodies of the teaching do not bind to CLD18A2 variants or fragments thereof, wherein one or more, preferably all of the amino acids at these positions are replaced by a different amino acid, in particular by those amino acids found at the corresponding positions within CLD18A1 (SEQ ID NO:8) (Ala42Ser, Asn45Gln and Glu56Gln).

[0017] Killing of cells by the antibody of the teaching is preferably induced by binding of the antibody to CLD18 expressed by said cells, more preferably by binding of the antibody to CLD18A2 expressed by said cells. In one embodiment, binding of the antibody of the teaching to CLD18A1 expressed by said cells does not induce killing of said cells. Such killing of cells can be utilized therapeutically as described herein. In particular, killing of cells can be utilized for treating or preventing cancer, in particular cancer metastasis and the metastatic spread of cancer cells.

[0018] The cells expressing CLD18 are preferably cancer cells and are, in particular, selected from the group consisting of tumorigenic gastric, esophageal, pancreatic, lung, ovarian, colon, hepatic, head-neck, and gallbladder cancer cells.

[0019] Preferably the antibody of the teaching mediates killing of cells by inducing complement dependent cytotoxicity (CDC) mediated lysis, antibody dependent cellular cytotoxicity (ADCC) mediated lysis, apoptosis, homotypic adhesion, and/or phagocytosis, preferably by inducing CDC mediated lysis and/or ADCC mediated lysis.

[0020] In one embodiment the antibody of the teaching does not induce CDC mediated lysis of cells.

[0021] Preferably, ADCC mediated lysis of cells takes place in the presence of effector cells, which in particular embodiments are selected from the group consisting of monocytes, mononuclear cells, NK cells and PMNs, and phagocytosis is by macrophages.

[0022] The antibody of the teaching may be a monoclonal, chimeric, human, or humanized antibody, or a fragment of an antibody and may be selected from the group consisting of an IgG1, an IgG2, preferably IgG2a and IgG2b, an IgG3, an IgG4, an IgM, an IgA1, an IgA2, a secretory IgA, an IgD, and an IgE antibody.

[0023] According to all aspects of the teaching, CLD18 is preferably human CLD18, preferably human CLD18A2, and CLD18A2 preferably has the amino acid sequence according to SEQ ID NO:2 and CLD18A1 preferably has the amino acid sequence according to SEQ ID NO:8.

[0024] In particular preferred embodiments, the antibody of the teaching binds to native epitopes of CLD18 present on the surface of living cells. In further preferred embodiments, the antibody of the teaching is specific for cancer cells, preferably stomach cancer cells.

[0025] In certain embodiments of the teaching CLD18 is expressed on the surface of cells.

[0026] Antibodies of the teaching may be obtained by a method comprising the step of immunizing an animal with a protein or peptide comprising an amino acid sequence selected from the group consisting of SEQ ID NO:2, 4, 6, 16, 18, 20, 21-23, 26-31, 151, 153, and 155-157 or an immunogenic fragment or derivative thereof, or a nucleic acid or host cell expressing said protein or peptide, or immunogenic fragment or derivative thereof. Preferably, an antibody of the teaching is specific for the afore mentioned proteins, peptides or immunogenic fragments or derivatives thereof. In the context of a protein or peptide used in immunization a derivative relates to a variant of such protein or peptide which has the same or similar immunogenic properties as the protein or peptide from which it is derived. In particular, the derivative of a protein or peptide when used in immunization for the production of antibodies, in particular monoclonal antibodies, provides antibodies having the same specificity as antibodies obtained when using the protein or peptide in immunization. For example, such derivative may include the deletion, substitution or addition of one or more amino acids. In particular, it may include the addition of one or more amino acids such as cysteine at either the N-terminus or C-terminus or both or the replacement of cysteine residues by serine residues. The data presented herein uncover amino acids within CLD18 which are not critical for antibody binding. Accordingly, CLD proteins, peptides, immunogenic fragments thereof or derivatives thereof as described herein used for immunization may incorporate one or more substitutions of amino acids at said amino acid positions which are not critical for antibody binding.

[0027] In a particularly preferred embodiment, the antibody of the teaching is produced by a clone having the accession no. DSM ACC2737 (182-D1106-055), DSM ACC2738 (182-D1106-056), DSM ACC2739 (182-D1106-057), DSM ACC2740 (182-D1106-058), DSM ACC2741 (182-D1106-059), DSM ACC2742 (182-D1106-062), DSM ACC2743 (182-D1106-067), DSM ACC2745 (182-D758-035), DSM ACC2746 (182-D758-036), DSM ACC2747 (182-D758-040), DSM ACC2748 (182-D1106-061), DSM ACC2808 (182-D1106-279), DSM ACC2809 (182-D1106-294), or DSM ACC2810 (182-D1106-362).

[0028] In one embodiment the antibody of the teaching is coupled to a therapeutic agent such as a toxin, a radioisotope, a drug or a cytotoxic agent.

[0029] In a further aspect the teaching relates to a hybridoma capable of producing the antibody of the teaching. Preferred hybridomas are those having the accession no. DSM ACC2737 (182-D1106-055), DSM ACC2738 (182-D1106-056), DSM ACC2739 (182-D1106-057), DSM ACC2740 (182-D1106-058), DSM ACC2741 (182-D1106-059), DSM ACC2742 (182-D1106-062), DSM ACC2743 (182-D1106-067), DSM ACC2745 (182-D758-035), DSM ACC2746 (182-D758-036), DSM ACC2747 (182-D758-040), DSM ACC2748 (182-D1106-061), DSM ACC2808 (182-D1106-279), DSM ACC2809 (182-D1106-294), or DSM ACC2810 (182-D1106-362).

[0030] Antibodies of the teaching are designated herein by referring to the designation of the antibody, e.g. 182-

D758-035, and/or by referring to the clone producing the antibody, e.g. 26D12.

[0031] The teaching also relates to a pharmaceutical composition comprising an antibody of the teaching and/or a conjugate thereof with a therapeutic agent, and a pharmaceutically acceptable carrier.

[0032] In a further aspect the teaching relates to a method of inhibiting growth and/or killing of a cell expressing CLD18, preferably CLD18A2, comprising contacting the cell with an effective amount of an antibody of the teaching and/or a conjugate thereof with a therapeutic agent. CLD18 is preferably expressed on the surface of said cell.

[0033] In a further aspect the teaching relates to a method of treating or preventing a disease or disorder involving cells expressing CLD18, preferably CLD18A2, comprising administering to a subject an antibody of the teaching, a conjugate thereof with a therapeutic agent, or a pharmaceutical composition comprising the antibody of the teaching or the conjugate thereof with a therapeutic agent. Preferably the disease or disorder is a tumor-related disease and in particular embodiments is selected from the group consisting of gastric cancer, esophageal cancer, pancreatic cancer, lung cancer, ovarian cancer, colon cancer, hepatic cancer, head-neck cancer, and cancer of the gallbladder, and the metastases originating therefrom. CLD18 is preferably expressed on the surface of said cells.

[0034] Preferably, the antibodies of the teaching have the ability to discriminate CLD18-variants expressed by different cell types including cancer cells and non-malignant cells. In a particularly preferred embodiment, the antibodies of the teaching have the ability to bind to CLD18A2 while they do not bind to CLD18A1, or bind to CLD18A1 with a lower specificity compared to the binding specificity to CLD18A2.

[0035] The term "binding" according to the teaching preferably relates to a specific binding. "Specific binding" means that an agent such as an antibody binds stronger to a target such as an epitope for which it is specific compared to the binding to another target. An agent binds stronger to a first target compared to a second target if it binds to the first target with a dissociation constant (K_D) which is lower than the dissociation constant for the second target. Preferably the dissociation constant (K_D) for the target to which the agent binds specifically is more than 10-fold, preferably more than 20-fold, more preferably more than 50-fold, even more preferably more than 100-fold, 200-fold, 500-fold or 1000-fold lower than the dissociation constant (K_D) for the target to which the agent does not bind specifically.

[0036] Preferably, antibodies of the teaching have a dissociation constant for CLD18, preferably CLD18A2 which is 10^{-6} M or less, preferably 10^{-7} M or less, preferably 10^{-8} M or less, or preferably 10^{-9} M or less. Preferably, antibodies of the teaching have a dissociation constant for CLD18, preferably CLD18A2 which is in the range of 10^{-8} M to 10^{-9} M.

[0037] The antibodies of the teaching mediate killing of cells expressing CLD18, preferably CLD18A2, by binding to CLD18, preferably expressed on the surface of said cells. In one embodiment, antibodies of the teaching induce complement dependent cytotoxicity (CDC), e.g. at least about 20-40% CDC mediated lysis, preferably about 40-50% CDC mediated lysis, and more preferably more than 50% CDC mediated lysis of cells expressing CLD18. Such antibodies are exemplified herein by the following antibodies: 37H8, 38G5, 38H3, 39F11, 61C2, 26B5, 26D12, 28D10, 163E12, 175D10, 45C1, 125E1, ch-163E12, and ch-175D10. Alternatively or in addition to inducing CDC, antibodies of the teaching may induce antibody dependent cellular cytotoxicity (ADCC) of cells expressing CLD18 in the presence of effector cells (e.g., monocytes, mononuclear cells, NK cells and PMNs). Such antibodies are exemplified herein by the following antibodies: 37G11, 37H8, 38G5, 38H3, 39F11, 43A11, 61C2, 26B5, 26D12, 28D10, 42E12, 163E12, 175D10, 45C1, and 125E1. Antibodies of the teaching may have the ability to induce apoptosis of cells expressing CLD18, induce homotypic adhesion of cells expressing CLD18 and/or induce phagocytosis of cells expressing CLD18 in the presence of macrophages. The antibodies of the teaching may have one or more of the above described functional properties. Preferably, antibodies of the teaching induce CDC mediated lysis and ADCC mediated lysis of cells expressing CLD18 and more preferably

induce ADCC mediated lysis of cells expressing CLD18 while they do not induce CDC mediated lysis of said cells. Exemplary target cells for antibodies of the present teaching include, but are not limited to, cancer cells expressing CLD18, preferably CLD18A2, such as tumorigenic gastric, pancreatic, esophageal and lung cancer cells. In a particular preferred embodiment, killing of cells mediated by antibodies of the teaching is CLD18A2 specific, i.e. antibodies of the teaching mediate killing of cells, preferably CDC and/or ADCC mediated lysis of cells, expressing CLD18A2 but do not mediate killing of cells expressing CLD18A1 but not expressing CLD18A2. The antibodies described above may be used to mediate killing of tumor cells in the treatment or prevention of cancer such as gastric cancer, esophageal cancer, pancreatic cancer, lung cancer, ovarian cancer, colon cancer, hepatic cancer, head-neck cancer, and cancer of the gallbladder and/or the metastases thereof.

[0038] Antibodies of the teaching may be categorized into distinct classes according to their binding properties and their ability to mediate effector function on cells expressing CLD18. The antibodies of the teaching may be categorized according to their

- binding properties to and/or effector functions mediated on cells expressing either CLD18A1 or CLD18A2 (discrimination of CLD18 splice variants),
- binding properties to and/or effector functions mediated on cells expressing either glycosylated or non-glycosylated CLD18 variants (discrimination betweeen CLD18-variants with and without N-glycosylation),
- binding properties to and/or effector functions mediated on either cancer cells or normal cell types (discrimination between CLD18-variants expressed by tumor cells or normal nonmalignant cells),
- binding properties to CLD18-epitopes masked by the formation of tight junctions,
- abilities to induce aggregate formation of CLD18 on living cells, and
- abilities to bind a non-human CLD18 variant, particularly CLD18 variants from mice, rats, rabbits and primates.

[0039] Antibodies of the teaching may have one or more of the following properties whereby reference is given to specific examples of antibodies of the teaching described herein (24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9, 45C1, 125E1, 163E12, 166E2, 175D10, ch-43A11, ch-45C1, ch-125E1, ch-163E12, ch-166E2, ch-175D10):

1. a) binding to CLD18A2 as well as to CLD18A1 (e.g. 26D12, 28D10, 37H8, 38H3, 39F11, 61C2, and 41C6)
2. b) binding to CLD18A2 but not to CLD18A1 (e.g. 26B5, 37G11, 38G5, 42E12, and 43A11, 45C1, 125E1, 163E12, 166E2, 175D10, ch-43A11, ch-45C1, ch-125E1, ch-163E12, ch-166E2, ch-175D10)
3. c) binding to CLD18 naturally expressed by tumor cells but not to CLD18 naturally expressed by **non-cancer** cells or tissues such as cells of stomach and lung (e.g 26B5, 75B8, 24H5, 39F11, 45C1, 125E1, 163E12, 166E2, 175D10).
4. d) mediating CDC induced killing of cells, which express CLD18A2 but not of cells which express CLD18A1 (e.g. 26D12, 28D10, 37H8, and 39F11, 163E12, ch-125E1, ch-163E12, ch-175D10)
5. e) mediating ADCC induced killing of cells expressing CLD18 (e.g. 26B5, 37G11, 37H8, 38G5, 38H3, 39F11, 43A11, 47D12, and 61C2, ch-163E12, ch-175D10)
6. f) mediating ADCC induced killing but not CDC mediated killing of cells expressing CLD18 (e.g. 37G11, 42E12, and 43A11)
7. g) mediating ADCC induced killing and CDC induced killing of cells expressing CLD18A2 (e.g. 37H8, 38H3, 39F11, ch-163E12, ch-175D10).

[0040] As exemplified herein, antibodies of the teaching further encompasses molecules, which

1. a) bind to differentiated cells of normal stomach, but not to stem cells of stomach (e.g. 39F11)
2. b) do not bind to normal gastric tissue as well as other normal organs but exclusively to cancer cells (e.g. 26B5)
3. c) bind to an epitope encompassing a non-glycosylated Asn at position 116 of CLD 18

4. d) which bind to human as well as to mouse CLD18 allowing to thoroughly perform preclinical toxicity studies in mice.

[0041] Antibodies of the teaching may be derived from different species, including but not limited to mouse, rat, rabbit, guinea pig and human. Antibodies of the teaching also include chimeric molecules in which an antibody constant region derived from one species, preferably human, is combined with the antigen binding site derived from another species. Moreover antibodies of the teaching include humanized molecules in which the antigen binding sites of an antibody derived from a non-human species are combined with constant and framework regions of human origin.

[0042] Antibodies of the teaching include polyclonal and monoclonal antibodies and include IgG2a (e.g. IgG2a, κ, λ), IgG2b (e.g. IgG2b, κ, λ), IgG3 (e.g. IgG3, κ, λ) and IgM antibodies. However, other antibody isotypes are also encompassed by the teaching, including IgG1, IgA1, IgA2, secretory IgA, IgD, and IgE antibodies. The antibodies can be whole antibodies or antigen-binding fragments thereof including, for example, Fab, $F(ab')_2$, Fv, single chain Fv fragments or bispecific antibodies. Furthermore, the antigen-binding fragments include binding-domain immunoglobulin fusion proteins comprising (i) a binding domain polypeptide (such as a heavy chain variable region or a light chain variable region) that is fused to an immunoglobulin hinge region polypeptide, (ii) an immunoglobulin heavy chain CH2 constant region fused to the hinge region, and (iii) an immunoglobulin heavy chain CH3 constant region fused to the CH2 constant region. Such binding-domain immunoglobulin fusion proteins are further disclosed in US2003/0118592 and US 2003/0133939.

[0043] Antibodies of the present teaching preferably dissociate from CLD18 with a dissociation equilibrium constant (KD) of approximately 1-100nM or less.

[0044] Preferably, antibodies of the teaching do not cross-react with related cell-surface antigens and thus do not inhibit their function.

[0045] In preferred embodiments, antibodies of the present teaching can be characterized by one or more of the following properties:

1. a) specificity for CLD18, in particular specificity for CLD18A2;
2. b) a binding affinity to CLD18, in particular CLD18A2, of about 100 nM or less, preferably, about 5-10 nM or less and, more preferably, about 1-3 nM or less,
3. c) the ability to mediate a high level of CDC on either CD55/59 negative or CD55/59 positive cells;
4. d) the ability to inhibit the growth of cells which express CLD18;
5. e) the ability to induce apoptosis of cells which express CLD18;
6. f) the ability to induce homotypic adhesion of cells which express CLD18;
7. g) the ability to induce ADCC of cells which express CLD18 in the presence of effector cells;
8. h) the ability to prolong survival of a subject having tumor cells which express CLD18;
9. i) the ability to deplete cells which express CLD18;
10. j) the ability to deplete cells which express low levels of CLD18 and/or
11. k) the ability to aggregate CLD18 on the surface of living cells

[0046] The anti-CLD18 antibodies of the present teaching can be derivatized, linked to or co-expressed to other binding specificities. In a particular embodiment, the teaching provides a bispecific or multispecific molecule comprising at least one first binding specificity for CLD18 (e.g., an anti-CLD18 antibody or mimetic thereof), and a second binding specificity for a effector cell, such as a binding specificity for an Fc receptor (e.g., a Fc-gamma receptor, such as Fc-gamma RI, or any other Fc receptor) or a T cell receptor, e.g., CD3.

[0047] Accordingly, the present teaching includes bispecific and multispecific molecules that bind to both CLD18

and to an Fc receptor or a T cell receptor, e.g. CD3. Examples of Fc receptors are IgG receptor, Fc-gamma receptor (FcγR), such as FcγRI (CD64), FcγRII (CD32), and FcγRIII (CD16). Other Fc receptors, such as IgA receptors (e.g., FcαRI), also can be targeted. The Fc receptor is preferably located on the surface of an effector cell, e.g., a monocyte, macrophage or an activated mononuclear cell. In a preferred embodiment, the bispecific and multispecific molecules bind to an Fc receptor at a site which is distinct from the immunoglobulin Fc (e.g., IgG or IgA) binding site of the receptor. Therefore, the binding of the bispecific and multispecific molecules is not blocked by physiological levels of immunoglobulins.

[0048] In yet another aspect, anti-CLD18 antibodies of the teaching are derivatized, linked to or co-expressed with another functional molecule, e.g., another peptide or protein (e.g., a Fab' fragment). For example, an antibody of the teaching can be functionally linked (e.g., by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other molecular entities, such as another antibody (e.g. to produce a bispecific or a multispecific antibody), a cytotoxin, cellular ligand or antigen (e.g. to produce an immunoconjugate, such as an immunotoxin). An antibody of the present teaching can be linked to other therapeutic moieties, e.g., a radioisotope, a small molecule anti-cancer drug, a recombinant cytokine or chemokine. Accordingly, the present teaching encompasses a large variety of antibody conjugates, bispecific and multispecific molecules, and fusion proteins, all of which bind to CLD18 expressing cells and which can be used to target other molecules to such cells.

[0049] In a further aspect, the teaching also envisions CLD18-binding proteins derived from non-immunoglobulin domains, in particular single-chain proteins. Such binding proteins and methods for their production are described, for example, in Binz et al. (2005) Nature Biotechnology 23 (10): 1257-1268. It is to be understood that the teaching given herein with respect to immunoglobulin or immunoglobulin derived binding molecules correspondingly also applies to binding molecules derived from non-immunoglobulin domains. In particular, using such binding molecules derived from non-immunoglobulin domains it is possible to block CLD18 of cells expressing said target and thus, to bring about therapeutic effects as disclosed herein for antibodies of the teaching, in particular the inhibition of proliferation of tumor cells. Although not mandatory, it is possible to confer effector functions of antibodies to such non-immunoglobulin binding molecules by e.g. fusion to the Fc region of antibodies.

[0050] In still another aspect, the teaching provides compositions, e.g., pharmaceutical and diagnostic compositions/kits, comprising a pharmaceutically acceptable carrier formulated along with one or a combination of antibodies of the teaching. In a particular embodiment, the composition includes a combination of antibodies which bind to distinct epitopes or which possess distinct functional characteristics, such as inducing CDC and/or ADCC and inducing apoptosis. In this embodiment of the teaching, antibodies may be used in combination, e. g., as a pharmaceutical composition comprising two or more anti-CLD18 monoclonal antibodies. For example, anti-CLD18 antibodies having different but complementary activities can be combined in a single therapy to achieve a desired therapeutic effect. In a preferred embodiment, the composition includes an anti-CLD18 antibody that mediates CDC combined with another anti-CLD18 antibody that induces apoptosis. In another embodiment, the composition includes an anti-CLD18 antibody that mediates highly effective killing of target cells in the presence of effector cells, combined with another anti-CLD18 antibody that inhibits the growth of cells expressing CLD18.

[0051] The present teaching also includes the simultaneous or sequential administration of two or more anti-CLD18 antibodies of the teaching, wherein at least one of said antibodies is a chimeric anti-CLD18 antibody and at least one further antibody is a human anti-CLD18 antibody, the antibodies binding to the same or different epitopes of CLD18. Preferably, a chimeric CLD18 antibody of the teaching is administered first followed by the administration of a human anti-CLD18 antibody of the teaching, wherein the human anti-CLD18 antibody is preferably administered for an extended period of time, i.e. as maintenance therapy.

[0052] Antibodies, immunoconjugates, bispecific and multispecific molecules and compositions of the present teaching can be used in a variety of methods for inhibiting growth of cells expressing CLD18, in particular CLD18A2 and/or selectively killing cells expressing CLD18, in particular CLD18A2 by contacting the cells with an effective amount of the antibody, immunconjugate, bispecific/multispecific molecule or composition, such that the

growth of the cell is inhibited and/or the cell is killed. In one embodiment, the method includes killing of the cell expressing CLD18, optionally in the presence of effector cells, for example, by CDC, apoptosis, ADCC, phagocytosis, or by a combination of two or more of these mechanisms. Cells expressing CLD18 which can be inhibited or killed using the antibodies of the teaching include cancer cells such as tumorigenic stomach, pancreatic, esophageal, lung, ovarian, colon, hepatic, head-neck, and gallbladder cells.

[0053] Accordingly, antibodies of the present teaching can be used to treat and/or prevent a variety of diseases involving cells expressing CLD18 by administering the antibodies to patients suffering from such diseases. Exemplary diseases that can be treated (e.g., ameliorated) or prevented include, but are not limited to, tumorigenic diseases. Examples of tumorigenic diseases, which can be treated and/or prevented include gastric cancer, pancreatic cancer, esophageal cancer, lung cancer, ovarian cancer, colorectal cancer, hepatic cancer, head-neck cancer, and cancer of the gallbladder, and the metastases thereof.

[0054] In a particular embodiment of the teaching, the subject being administered the antibody is additionally treated with a chemotherapeutic agent, radiation, or an agent that modulates, e.g., enhances or inhibits, the expression or activity of an Fc receptor, e.g. an Fc-gamma receptor, such as a cytokine. Typical cytokines for administration during treatment include granulocyte colony-stimulating factor (G-CSF), granulocyte-macrophage colony-stimulating factor (GM-CSF), interferon-γ (IFN-γ), and tumor necrosis factor (TNF). Typical therapeutic agents include, among others, anti-neoplastic agents such as doxorubicin, cisplatin, taxotere, 5-fluoruracil, methotrexat, gemzitabin and cyclophosphamide.

[0055] In yet another aspect, the teaching relates to an immunization strategy to immunize non-human animals such as mice with human CLD18 or a peptide fragment thereof, preferably CLD18A2 or a peptid fragment thereof to obtain antibodies. Preferred peptides for immunization are those selected from the group consisting of SEQ ID NO:2, 4, 6, 16, 18, 20-23, 26-31, 151, 153, and 155-157, or peptides comprising said sequences. Accordingly, in preferred embodiments, the antibodies of the teaching are those obtained by immunization using peptides selected from the group consisting of SEQ ID NO:2, 4, 6, 16, 18, 20-23, 26-31, 151, 153, and 155-157, or using peptides comprising said sequences. Analogously, antibodies to CLD18 can be generated in a transgenic non-human animal, such as a transgenic mouse. The transgenic non-human animal may be a transgenic mouse having a genome comprising a heavy chain transgene and a light chain transgene encoding all or a portion of an antibody.

[0056] Wildtype as well as transgenic non-human animals can be immunized with a purified or enriched preparation of CLD18 antigen and/or nucleic acids and/or cells expressing CLD18 or a peptide fragment thereof. Preferably, the non-human animal, is capable of producing multiple isotypes of human monoclonal antibodies to CLD18 (e.g., IgG, IgA and/or IgM) by undergoing V-D-J recombination and isotype switching. Isotype switching may occur by e.g., classical or non-classical isotype switching.

[0057] Accordingly, in yet another aspect, the teaching provides isolated B cells from a non-human animal as described above. The isolated B cells can then be immortalized by fusion to an immortalized cell to provide a source (e.g., a hybridoma) of antibodies of the teaching. Such hybridomas (i.e., which produce antibodies of the teaching) are also included within the scope of the teaching.

[0058] As exemplified herein, antibodies of the teaching can be obtained directly from hybridomas which express the antibody, or can be cloned and recombinantly expressed in a host cell (e.g., a CHO cell, or a lymphocytic cell). Further examples of host cells are microorganisms, such as E. coli, and fungi, such as yeast. Alternatively, they can be produced recombinantly in a transgenic non-human animal or plant.

[0059] Preferred hybridoma cells for producing antibodies of the teaching are those sequenced or deposited at the DSMZ (Mascheroder Weg 1b, 31824 Braunschweig, Germany; new address: Inhoffenstr. 7B, 31824 Braunschweig, Germany) having the following designations and accession numbers:

1. a. 182-D1106-055, accesssion no. DSM ACC2737, deposited on October 19, 2005

2. b. 182-D1106-056, accesssion no. DSM ACC2738, deposited on October 19, 2005
3. c. 182-D1106-057, accesssion no. DSM ACC2739, deposited on October 19, 2005
4. d. 182-D1106-058, accesssion no. DSM ACC2740, deposited on October 19, 2005
5. e. 182-D1106-059, accesssion no. DSM ACC2741, deposited on October 19, 2005
6. f. 182-D1106-062, accesssion no. DSM ACC2742, deposited on October 19, 2005,
7. g. 182-D1106-067, accesssion no. DSM ACC2743, deposited on October 19, 2005
8. h. 182-D758-035, accesssion no. DSM ACC2745, deposited on Nov. 17, 2005
9. i. 182-D758-036, accesssion no. DSM ACC2746, deposited on Nov. 17, 2005
10. j. 182-D758-040, accesssion no. DSM ACC2747, deposited on Nov. 17, 2005
11. k. 182-D1106-061, accesssion no. DSM ACC2748, deposited on Nov. 17, 2005
12. l. 182-D1106-279, accesssion no. DSM ACC2808, deposited on Oct. 26, 2006
13. m. 182-D1106-294, accesssion no. DSM ACC2809, deposited on Oct. 26, 2006,
14. n. 182-D1106-362, accesssion no. DSM ACC2810, deposited on Oct. 26, 2006.

[0060] Preferred antibodies of the teaching are those produced by and obtainable from the above-described hybridomas; i.e. 37G11 in the case of 182-D1106-055, 37H8 in the case of 182-D1106-056, 38G5 in the case of 182-D1106-057, 38H3 in the case of 182-D1106-058, 39F11 in the case of 182-D1106-059, 43A11 in the case of 182-D1106-062, 61C2 in the case of 182-D1106-067, 26B5 in the case of 182-D758-035, 26D12 in the case of 182-D758-036, 28D10 in the case of 182-D758-040, 42E12 in the case of 182-D1106-061, 125E1 in the case of 182-D1106-279, 163E12 in the case of 182-D1106-294, and 175D10 in the case of 182-D1106-362; and the chimerized and humanized forms thereof.

[0061] In preferred embodiments, antibodies, in particular chimerised forms of antibodies according to the teaching include antibodies comprising a heavy chain constant region (CH) comprising an amino acid sequence derived from a human heavy chain constant region such as the amino acid sequence represented by SEQ ID NO: 46 or 150 or a fragment thereof. In further preferred embodiments, antibodies, in particular chimerised forms of antibodies according to the teaching include antibodies comprising a light chain constant region (CL) comprising an amino acid sequence derived from a human light chain constant region such as the amino acid sequence represented by SEQ ID NO: 41 or 148 or a fragment thereof. In a particular preferred embodiment, antibodies, in particular chimerised forms of antibodies according to the teaching include antibodies which comprise a CH comprising an amino acid sequence derived from a human CH such as the amino acid sequence represented by SEQ ID NO: 46 or 150 or a fragment thereof and which comprise a CL comprising an amino acid sequence derived from a human CL such as the amino acid sequence represented by SEQ ID NO: 41 or 148 or a fragment thereof.

[0062] A CH comprising the amino acid sequence represented by SEQ ID NO: 46 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 45. A CH comprising the amino acid sequence represented by SEQ ID NO: 150 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 149. A CL comprising the amino acid sequence represented by SEQ ID NO: 41 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 40. A CL comprising the amino acid sequence represented by SEQ ID NO: 148 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 147.

[0063] In certain preferred embodiments, chimerised forms of antibodies include antibodies comprising a heavy chain comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 115, 116, 117, 118, 119, 120, and a fragment thereof and/or comprising a light chain comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 121, 122, 123, 124, 125, 126, 127, 128, 129, and a fragment thereof.

[0064] In certain preferred embodiments, chimerised forms of antibodies include antibodies comprising a combination of heavy chains and light chains selected from the following possibilities (i) to (ix):

1. (i) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 115 or a fragment

thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 122 or a fragment thereof,

2. (ii) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 116 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 121 or a fragment thereof,
3. (iii) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 117 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 123 or a fragment thereof,
4. (iv) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 119 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 126 or a fragment thereof,
5. (v) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 118 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 125 or a fragment thereof,
6. (vi) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 120 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 124 or a fragment thereof,
7. (vii) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 120 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 127 or a fragment thereof,
8. (viii) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 120 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 128 or a fragment thereof, and
9. (ix) the heavy chain comprises an amino acid sequence represented by SEQ ID NO: 120 or a fragment thereof and the light chain comprises an amino acid sequence represented by SEQ ID NO: 129 or a fragment thereof.

[0065] "Fragment" or "fragment of an amino acid sequence" as used above relates to a part of an antibody sequence, i.e. a sequence which represents the antibody sequence shortened at the N- and/or C-terminus, which when it replaces said antibody sequence in an antibody retains binding of said antibody to CLD18 and preferably functions of said antibody as described herein, e.g. CDC mediated lysis or ADCC mediated lysis. Preferably, a fragment of an amino acid sequence comprises at least 80%, preferably at least 90%, 95%, 96%, 97%, 98%, or 99% of the amino acid residues from said amino acid sequence. A fragment of an amino acid sequence selected from the group consisting of SEQ ID NO: 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, and 129 preferably relates to said sequence wherein 17, 18, 19, 20, 21, 22 or 23 amino acids at the N-terminus are removed. Fragments of amino acid sequences described herein may be encoded by respective fragments of nucleic acid sequences encoding said amino acid sequences.

[0066] A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 115 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 100. A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 116 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 101. A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 117 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 102. A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 119 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 104. A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 118 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 103. A heavy chain comprising an amino acid sequence represented by SEQ ID NO: 120 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 105.

[0067] A light chain comprising an amino acid sequence represented by SEQ ID NO: 122 may be encoded by a

nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 107. A light chain comprising an amino acid sequence represented by SEQ ID NO: 121 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 106. A light chain comprising an amino acid sequence represented by SEQ ID NO: 123 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 108. A light chain comprising an amino acid sequence represented by SEQ ID NO: 126 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 111. A light chain comprising an amino acid sequence represented by SEQ ID NO: 125 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 110. A light chain comprising an amino acid sequence represented by SEQ ID NO: 124 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 109. A light chain comprising an amino acid sequence represented by SEQ ID NO: 127 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 112. A light chain comprising an amino acid sequence represented by SEQ ID NO: 128 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 113. A light chain comprising an amino acid sequence represented by SEQ ID NO: 129 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 114.

[0068] In a preferred embodiment, an antibody of the teaching comprises a heavy chain variable region (VH) comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 132, 133, 134, 135, 136, 137, and a fragment thereof.

[0069] In a preferred embodiment, an antibody of the teaching comprises a light chain variable region (VL) comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 138, 139, 140, 141, 142, 143, 144, 145, 146, and a fragment thereof.

[0070] In certain preferred embodiments, an antibody of the teaching comprises a combination of heavy chain variable region (VH) and light chain variable region (VL) selected from the following possibilities (i) to (ix):

1. (i) the VH comprises an amino acid sequence represented by SEQ ID NO: 132 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 139 or a fragment thereof,
2. (ii) the VH comprises an amino acid sequence represented by SEQ ID NO: 133 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 138 or a fragment thereof,
3. (iii) the VH comprises an amino acid sequence represented by SEQ ID NO: 134 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 140 or a fragment thereof,
4. (iv) the VH comprises an amino acid sequence represented by SEQ ID NO: 136 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 143 or a fragment thereof,
5. (v) the VH comprises an amino acid sequence represented by SEQ ID NO: 135 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 142 or a fragment thereof,
6. (vi) the VH comprises an amino acid sequence represented by SEQ ID NO: 137 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 141 or a fragment thereof,
7. (vii) the VH comprises an amino acid sequence represented by SEQ ID NO: 137 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 144 or a fragment thereof,
8. (viii) the VH comprises an amino acid sequence represented by SEQ ID NO: 137 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 145 or a fragment thereof,
9. (ix) the VH comprises an amino acid sequence represented by SEQ ID NO: 137 or a fragment thereof and the VL comprises an amino acid sequence represented by SEQ ID NO: 146 or a fragment thereof.

[0071] A VH comprising an amino acid sequence represented by SEQ ID NO: 132 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 55. A VH comprising an amino acid sequence represented by SEQ ID NO: 133 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 56. A VH comprising an amino acid sequence represented by SEQ ID NO: 134 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 57. A VH comprising an amino acid sequence represented by SEQ ID NO: 136 may be encoded by a nucleic acid

comprising the nucleic acid sequence represented by SEQ ID NO: 59. A VH comprising an amino acid sequence represented by SEQ ID NO: 135 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 58. A VH comprising an amino acid sequence represented by SEQ ID NO: 137 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 60.

[0072] A VL comprising an amino acid sequence represented by SEQ ID NO: 139 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 62. A VL comprising an amino acid sequence represented by SEQ ID NO: 138 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 61. A VL comprising an amino acid sequence represented by SEQ ID NO: 140 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 63. A VL comprising an amino acid sequence represented by SEQ ID NO: 143 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 66. A VL comprising an amino acid sequence represented by SEQ ID NO: 142 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 65. A VL comprising an amino acid sequence represented by SEQ ID NO: 141 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 64. A VL comprising an amino acid sequence represented by SEQ ID NO: 144 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 67. A VL comprising an amino acid sequence represented by SEQ ID NO: 145 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 68. A VL comprising an amino acid sequence represented by SEQ ID NO: 146 may be encoded by a nucleic acid comprising the nucleic acid sequence represented by SEQ ID NO: 69.

[0073] In a preferred embodiment, an antibody of the teaching comprises a VH comprising a set of complementarity-determining regions CDR1, CDR2 and CDR3 selected from the following embodiments (i) to (vi):

1. (i) CDR1: positions 45-52 of SEQ ID NO: 115, CDR2: positions 70-77 of SEQ ID NO: 115, CDR3: positions 116-125 of SEQ ID NO: 115,
2. (ii) CDR1: positions 45-52 of SEQ ID NO: 116, CDR2: positions 70-77 of SEQ ID NO: 116, CDR3: positions 116-126 of SEQ ID NO: 116,
3. (iii) CDR1: positions 45-52 of SEQ ID NO: 117, CDR2: positions 70-77 of SEQ ID NO: 117, CDR3: positions 116-124 of SEQ ID NO: 117,
4. (iv) CDR1: positions 45-52 of SEQ ID NO: 118, CDR2: positions 70-77 of SEQ ID NO: 118, CDR3: positions 116-126 of SEQ ID NO: 118,
5. (v) CDR1: positions 44-51 of SEQ ID NO: 119, CDR2: positions 69-76 of SEQ ID NO: 119, CDR3: positions 115-125 of SEQ ID NO: 119, and
6. (vi) CDR1: positions 45-53 of SEQ ID NO: 120, CDR2: positions 71-78 of SEQ ID NO: 120, CDR3: positions 117-128 of SEQ ID NO: 120.

[0074] In a preferred embodiment, an antibody of the teaching comprises a VL comprising a set of complementarity-determining regions CDR1, CDR2 and CDR3 selected from the following embodiments (i) to (ix):

1. (i) CDR1: positions 47-58 of SEQ ID NO: 121, CDR2: positions 76-78 of SEQ ID NO: 121, CDR3: positions 115-123 of SEQ ID NO: 121,
2. (ii) CDR1: positions 49-53 of SEQ ID NO: 122, CDR2: positions 71-73 of SEQ ID NO: 122, CDR3: positions 110-118 of SEQ ID NO: 122,
3. (iii) CDR1: positions 47-52 of SEQ ID NO: 123, CDR2: positions 70-72 of SEQ ID NO: 123, CDR3: positions 109-117 of SEQ ID NO: 123,
4. (iv) CDR1: positions 47-58 of SEQ ID NO: 124, CDR2: positions 76-78 of SEQ ID NO: 124, CDR3: positions 115-123 of SEQ ID NO: 124,
5. (v) CDR1: positions 47-58 of SEQ ID NO: 125, CDR2: positions 76-78 of SEQ ID NO: 125, CDR3: positions 115-123 of SEQ ID NO: 125,
6. (vi) CDR1: positions 47-58 of SEQ ID NO: 126, CDR2: positions 76-78 of SEQ ID NO: 126, CDR3: positions 115-122 of SEQ ID NO: 126,

7. (vii) CDR1: positions 47-58 of SEQ ID NO: 127, CDR2: positions 76-78 of SEQ ID NO: 127, CDR3: positions 115-123 of SEQ ID NO: 127,
8. (viii) CDR1: positions 47-58 of SEQ ID NO: 128, CDR2: positions 76-78 of SEQ ID NO: 128, CDR3: positions 115-123 of SEQ ID NO: 128, and
9. (ix) CDR1: positions 47-52 of SEQ ID NO: 129, CDR2: positions 70-72 of SEQ ID NO: 129, CDR3: positions 109-117 of SEQ ID NO: 129.

[0075] In a preferred embodiment, an antibody of the teaching comprises a combination of VH and VL each comprising a set of complementarity-determining regions CDR1, CDR2 and CDR3 selected from the following embodiments (i) to (ix):

1. (i) VH: CDR1: positions 45-52 of SEQ ID NO: 115, CDR2: positions 70-77 of SEQ ID NO: 115, CDR3: positions 116-125 of SEQ ID NO: 115, VL: CDR1: positions 49-53 of SEQ ID NO: 122, CDR2: positions 71-73 of SEQ ID NO: 122, CDR3: positions 110-118 of SEQ ID NO: 122,
2. (ii) VH: CDR1: positions 45-52 of SEQ ID NO: 116, CDR2: positions 70-77 of SEQ ID NO: 116, CDR3: positions 116-126 of SEQ ID NO: 116, VL: CDR1: positions 47-58 of SEQ ID NO: 121, CDR2: positions 76-78 of SEQ ID NO: 121, CDR3: positions 115-123 of SEQ ID NO: 121,
3. (iii) VH: CDR1: positions 45-52 of SEQ ID NO: 117, CDR2: positions 70-77 of SEQ ID NO: 117, CDR3: positions 116-124 of SEQ ID NO: 117, VL: CDR1: positions 47-52 of SEQ ID NO: 123, CDR2: positions 70-72 of SEQ ID NO: 123, CDR3: positions 109-117 of SEQ ID NO: 123,
4. (iv) VH: CDR1: positions 44-51 of SEQ ID NO: 119, CDR2: positions 69-76 of SEQ ID NO: 119, CDR3: positions 115-125 of SEQ ID NO: 119, VL: CDR1: positions 47-58 of SEQ ID NO: 126, CDR2: positions 76-78 of SEQ ID NO: 126, CDR3: positions 115-122 of SEQ ID NO: 126,
5. (v) VH: CDR1: positions 45-52 of SEQ ID NO: 118, CDR2: positions 70-77 of SEQ ID NO: 118, CDR3: positions 116-126 of SEQ ID NO: 118, VL: CDR1: positions 47-58 of SEQ ID NO: 125, CDR2: positions 76-78 of SEQ ID NO: 125, CDR3: positions 115-123 of SEQ ID NO: 125,
6. (vi) VH: CDR1: positions 45-53 of SEQ ID NO: 120, CDR2: positions 71-78 of SEQ ID NO: 120, CDR3: positions 117-128 of SEQ ID NO: 120, VL: CDR1: positions 47-58 of SEQ ID NO: 124, CDR2: positions 76-78 of SEQ ID NO: 124, CDR3: positions 115-123 of SEQ ID NO: 124,
7. (vii) VH: CDR1: positions 45-53 of SEQ ID NO: 120, CDR2: positions 71-78 of SEQ ID NO: 120, CDR3: positions 117-128 of SEQ ID NO: 120, VL: CDR1: positions 47-58 of SEQ ID NO: 127, CDR2: positions 76-78 of SEQ ID NO: 127, CDR3: positions 115-123 of SEQ ID NO: 127,
8. (viii) VH: CDR1: positions 45-53 of SEQ ID NO: 120, CDR2: positions 71-78 of SEQ ID NO: 120, CDR3: positions 117-128 of SEQ ID NO: 120, VL: CDR1: positions 47-58 of SEQ ID NO: 128, CDR2: positions 76-78 of SEQ ID NO: 128, CDR3: positions 115-123 of SEQ ID NO: 128, and
9. (ix) VH: CDR1: positions 45-53 of SEQ ID NO: 120, CDR2: positions 71-78 of SEQ ID NO: 120, CDR3: positions 117-128 of SEQ ID NO: 120, VL: CDR1: positions 47-52 of SEQ ID NO: 129, CDR2: positions 70-72 of SEQ ID NO: 129, CDR3: positions 109-117 of SEQ ID NO: 129.

[0076] In further preferred embodiments, an antibody of the teaching preferably comprises one or more of the complementarity-determining regions (CDRs), preferably at least the CDR3 variable region, of the heavy chain variable region (VH) and/or of the light chain variable region (VL) of a monoclonal antibody against CLD18, preferably of a monoclonal antibody against CLD18 described herein, and preferably comprises one or more of the complementarity-determining regions (CDRs), preferably at least the CDR3 variable region, of the heavy chain variable regions (VH) and/or light chain variable regions (VL) described herein. In one embodiment said one or more of the complementarity-determining regions (CDRs) are selected from a set of complementarity-determining regions CDR1, CDR2 and CDR3 described herein. In a particularly preferred embodiment, an antibody of the teaching preferably comprises the complementarity-determining regions CDR1, CDR2 and CDR3 of the heavy chain variable region (VH) and/or of the light chain variable region (VL) of a monoclonal antibody against CLD18, preferably of a monoclonal antibody against CLD18 described herein, and preferably comprises the

complementarity-determining regions CDR1, CDR2 and CDR3 of the heavy chain variable regions (VH) and/or light chain variable regions (VL) described herein.

[0077] In one embodiment an antibody of the teaching comprising one or more CDRs, a set of CDRs or a combination of sets of CDRs as described herein comprises said CDRs together with their intervening framework regions. Preferably, the portion will also include at least about 50% of either or both of the first and fourth framework regions, the 50% being the C-terminal 50% of the first framework region and the N-terminal 50% of the fourth framework region. Construction of antibodies of the present teaching made by recombinant DNA techniques may result in the introduction of residues N- or C-terminal to the variable regions encoded by linkers introduced to facilitate cloning or other manipulation steps, including the introduction of linkers to join variable regions of the teaching to further protein sequences including immunoglobulin heavy chains, other variable domains (for example in the production of diabodies) or protein labels.

[0078] In one embodiment an antibody of the teaching comprising one or more CDRs, a set of CDRs or a combination of sets of CDRs as described herein comprises said CDRs in a human antibody framework.

[0079] Reference herein to an antibody comprising with respect to the heavy chain thereof a particular chain, or a particular region or sequence preferably relates to the situation wherein all heavy chains of said antibody comprise said particular chain, region or sequence. This applies correspondingly to the light chain of an antibody.

[0080] The present teaching also relates to nucleic acids comprising genes or nucleic acid sequences encoding antibodies or parts thereof, e.g. an antibody chain, as described herein. The nucleic acids may be comprised in a vector, e.g., a plasmid, cosmid, virus, bacteriophage or another vector used e.g. conventionally in genetic engineering. The vector may comprise further genes such as marker genes which allow for the selection of the vector in a suitable host cell and under suitable conditions. Furthermore, the vector may comprise expression control elements allowing proper expression of the coding regions in suitable hosts. Such control elements are known to the artisan and may include a promoter, a splice cassette, and a translation initiation codon.

[0081] Preferably, the nucleic acid of the teaching is operatively attached to the above expression control sequences allowing expression in eukaryotic or prokaryotic cells. Control elements ensuring expression in eukaryotic or prokaryotic cells are well known to those skilled in the art.

[0082] Methods for construction of nucleic acid molecules according to the present teaching, for construction of vectors comprising the above nucleic acid molecules, for introduction of the vectors into appropriately chosen host cells, for causing or achieving the expression are well-known in the art.

[0083] A further aspect of the present teaching relates to a host cell comprising a nucleic acid or vector as disclosed herein.

[0084] Other features and advantages of the instant teaching will be apparent from the following detailed description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0085]

Fig. 1 shows an immunfluorescence analysis of HEK293 cells transfected with CLD18A2 coupled to a green fluorochrome and reacted with mouse serum after DNA immunisation with SEQ ID NO: 15 fused to a helper epitope.

Fig. 2 shows a Western blot analysis of HEK293 cells transfected with CLD18A2-myc (SEQ ID NO: 3) and untransfected HEK293 cells with the monoclonal mouse-anti-c-myc antibody 9E11 (Serotec, CRL MCA2200).

Fig. 3 shows an immunfluorescence analysis using CHO cells transfected with CLD18A2 and a polyclonal rabbit-anti-CLD18 antibody (Zymed, CRL 38-8000).

Fig. 4A and B show the binding of hybridoma supernatants 24H5 and 85A3 to HEK293 cells transiently transfected with human CLD18A2 and a fluorescent marker as determined by flow cytometry. Figure 4C shows the binding of hybridoma supernatants 45C1, 125E1, 163E12, 166E2 and 175D10 to HEK293 cells stably transfected with human CLD18A2 and counterstained with propidium iodide.

Fig. 5 shows binding of hybridoma supernatants 24H5 (A), 9E8 (B), 26B5 (C) and 19B9 (D) to HEK293 cells transiently transfected with a fluorescent marker and either human CLD18A2 or CLD18A2-Myc or CLD18A2-HA as analyzed by flow cytometry.

Fig. 6A and B show binding of hybridoma supernatants 37H8, 43A11, 45C1 and 163E12 to HEK293 cells stably transfected with either human CLD18A2 or CLD18A1 as determined by flow cytometry.

Fig. 7 shows an immunofluorescence analysis of the CLD18A2 isoform specific monoclonal antibody 37G11 by staining HEK293 cells transfected with CLD18A2 (A, C) and CLD18A1 (B, D), respectively, under native (A, B) and paraformaldehyde fixation (C, D) conditions.

Fig. 8 shows an immunfluorescence analysis of the CLD18 monoclonal antibody 26B5 by staining HEK293 cells transfected with CLD18A2 (A, C) and CLD18A1 (B, D), respectively, under native (A, B) and paraformaldehyde fixation (C, D) conditions.

Fig. 9. Cell line RT-PCR RT-PCR analyis with CLD18A2-specific primers showed clear expression in 4/5 tested cell lines.

Fig. 10 shows an immunfluorescence analysis of DAN-G cells (subclone F2) and a polyclonal rabbit-anti-CLD18 antibody (Zymed, CRL 38-8000).

Fig. 11 shows an immunfluorescence analysis of KATO-III cells (subclone 3B9 4D5) and a polyclonal rabbit-anti-CLD18 antibody (Zymed, CRL 38-8000).

Fig. 12 A shows an immunfluorescence analysis of SNU-16 cells (subclone G5) with a polyclonal rabbit-anti-CLD18 antibody (Zymed, CRL 38-8000). Fig. 12 B shows an immunfluorescence analysis of KATO-III cells with monoclonal antibodies of the teaching.

Fig. 13 shows surface expression of CLD18 on KATO-III and NUGC-4 cells as analyzed by staining of cells with monoclonal antibodies 61C2 and 163E12 followed by flow cytometrical analysis.

Fig. 14. Protein-alignment of human CLD18A1 (NP_057453), human CLD18A2 (NP_001002026), mouse CLD18A1 (NP_062789) and mouse CLD18A2 (AAL15636).

Fig. 15 A and B show binding of hybridoma supernatants 38G5, 38H3, 37G11, 45C1, and 163E12, respectively, to HEK293 cells transiently transfected with a fluorescent marker and either murine CLD18A1 or murine CLD18A2 as analyzed by flow cytometry.

Fig. 16. Immunhistochemical analyses with polyclonal AB p105. Immunhistochemical stainings on a subset of normal tissues (stomach, lung, bone marrow and prostate) confirm gastric tissue specificity (A). Expression was also detected in stomach carcinomas (upper row) and lung carcinomas (B). Only differentiated cells but not stem cells do express CLD18A2 (C).

Fig. 17. Immunhistochemical analyses with monoclonal AB 39F11D7

1. (A) Specific protein expression was detected in normal stomach mucosa, whereas all other tested normal tissue were negative.
2. (B) Strong CLD18A2 expression was found in stomach and lung carcinomas.

Fig. 18. Immunhistochemical analyses with monoclonal AB 26B5 (A), 175D10 (B), 43A11 (C), 163E12 (D), and

45C1 (E). All antibodies show strong staining of HEK293-CLD18A2 xenograft tumors and gastric cancer specimens, but not HEK293-Mock control-transfected tumors.

Fig. 19 is a graph comparing the percentage of dead cells after induction of CDC by 85A3, 28D10, 24H5, or 26D12 against HEK293 cells stably transfected with human CLD18A2 using flow cytometry.

Fig. 20 is a graph comparing the percentage of specific cell lysis after induction of CDC by 24H5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, or 61C2 against adherent CHO cells stably transfected with either human CLD18A2 or human CLD18A1 as determined by fluorescence measurement.

Fig. 21 shows concentration-dependent induction of CDC against CHO cells stably transfected with human CLD18A2 by 75B8 (A), 28D10 (B), or 37H8 (C) as determined by fluorescence measurement.

Fig. 22 shows lysis of HEK293-CLD18A2 cells by 26B5, 37H8, 38G5, 47D12, and 61C2, respectively, in the presence of MNCs.

Fig. 23 shows lysis of HEK293-CLD18A1 cells by 26B5, 37H8, 38G5, 47D12, and 61C2, respectively, in the presence of MNCs.

Fig. 24 shows tumor growth inhibition by antibodies of the teaching in an early treatment xenograft model with HEK293-CLD18A2 cells.

Fig. 25A and B show prolonged survival by treatment with antibodies of the teaching in two early treatment xenograft models with HEK293-CLD18A2 cells.

Fig. 26 shows prolongation of survival by antibodies of the teaching in an advanced treatment xenograft model with HEK293-CLD18A2 cells.

Fig. 27A shows tumor growth inhibition by antibodies of the teaching in an early treatment xenograft model. Fig. 27B shows prolongation of survival by antibodies of the teaching in an early treatment xenograft model. Endogenously CLD18A2 expressing DAN-G cells were used.

Fig. 28 shows CLD18A2 mRNA expression in mouse tissues. RT-PCR investigations with CLD18A2-specfic primers showed no significant expression within all tested normal tissues except stomach. The following normal tissues were analysed: 1: small intestine, 2: spleen, 3: skin, 4: stomach, 5: lung, 6: pancreas, 7: lymph node, 8: thymus, 9: negative control

Fig. 29 shows CLD18 expression in normal stomach. Immunohistochemical analysis with CLD18 specific antibody of mouse stomach reveals conserved expression pattern. While the surface epithelia and deeper crypts express CLD18 in their cell surface, the central neck region is CLD18 negative.

Fig. 30 shows haematoxylin and eosin staining of mice stomach tissues. Shown is in overview (A) and in detail (B) the stomach of a 37G11 -treated mouse in comparison to a control mouse (C and D), which was treated with PBS only.

Fig 31A and B show flowcytometric staining of HEK293 cells stably transfected with human CLD18A1 and A2, respectively, as well as endogenously expressing KATO-III cells with antibodies of the teaching (43A11, 125E1, 163E12, 166E2, and 175D10).

Fig. 32 shows CDC on CLD18A2 expressing cells mediated by chimeric antibodies of the teaching.

Fig. 33 shows ADCC on KATO-III cells mediated by chimeric antibodies of the teaching.

Fig. 34 shows prolonged survival by treatment with chimeric antibodies ch-175D10 and ch-163E12 in an early treatment xenograft model.

Fig. 35 shows prolongation of survival by treatment with chimeric antibodies ch-175D10 and ch-163E12 in an advanced treatment xenograft model.

Fig. 36 shows epitope mapping experiments with antibodies ch-175D10 and ch163E12. The amino acid sequence of the first extracellular domain of CLD18A2 without modifications (upper row, no Cys-Ser exchange) or with a cysteine-serine exchange (lower row, Cys-Ser exchange) was analysed.

Fig. 37 shows three different protein folding models for the first extracellular domain of CLD18A2.

Fig. 38A, B and C show binding of ch-175D10, ch-163E12 and ch-125E1 to HEK293 cells transiently transfected with a fluorescent marker and either murine CLD18A1 / CLD18A2 or human CLD18A1 / CLD18A2 as analyzed by flow cytometry. Only transfected cells were analysed and dead cells were excluded from analysis by PI staining.

Fig. 39 shows high level of CLD18A2 plasma membrane expression in primary gastric tumors and gastric cancer metastatis. Unselected specimen from primary gastric cancer and gastric cancer metastasis (Krukenberg tumors & lymph nodes) were stained with a GC182 specific rabbit antiserum. Immunohistochemistry as well as evaluation of staining intensity (neg, weak=1, moderate=2, strong=3) and proportion of tumor cells showing a plasma membrane staining (0-100%) was performed by professional clinical pathologists. Each circle respresent an independent tumor specimen. Statistically significant increased staining intensity in metastases was observed (p=0,034, Fisher's exact test)

DETAILED DESCRIPTION

[0086] The antibodies described herein may be isolated monoclonal antibodies which specifically bind to an epitope present on CLD18, preferably an epitope located within the extracellular domains of CLD18, in particular the first extracellular domain. Isolated monoclonal antibodies encompassed by the present teaching include IgA, IgG1-4, IgE, IgM, and IgD antibodies. In one embodiment the antibody is an IgG1 antibody, more particularly an IgG1, kappa or IgG1, lambda isotype. In another embodiment the antibody is an IgG3 antibody, more particularly an IgG3, kappa or IgG3, lambda isotype. In yet another embodiment the antibody is an IgG4 antibody, more particularly an IgG4, kappa or IgG4, lambda isotype. In still another embodiment the antibody is an IgA1 or IgA2 antibody. In still another embodiment the antibody is an IgM antibody.

[0087] In one embodiment the teaching relates to antibodies which specifically bind to cells expressing CLD18, and preferably (i) bind to cells expressing CLD18A2, and (ii) do not bind to cells not expressing CLD18A2 but expressing CLD18A1. The antibodies of the teaching preferably (i) mediate killing of cells expressing CLD18A2, and (ii) do not mediate killing of cells not expressing CLD18A2 but expressing CLD18A1.

[0088] In another embodiment, the teaching relates to antibodies which (i) bind to tumor cells expressing CLD18, (ii) do not bind to CLD18 expressing cells of normal stomach mucosa, and/or (iii) do not bind to CLD18 expressing cells of non-cancer lung tissue.

[0089] The teaching also includes antibodies which (i) mediate killing of tumor cells expressing CLD18, (ii) do not mediate killing of CLD18 expressing cells of normal stomach mucosa, and/or (iii) do not mediate killing of CLD18 expressing cells of non-cancer lung tissue.

[0090] In particular embodiments, the antibodies of the teaching (i) bind to an epitope on CLD18A2 which is not present on CLD18A1, preferably SEQ ID NO: 21, 22, and 23, (ii) bind to an epitope localized on the CLD18A2-loop1, preferably SEQ ID NO: 28, (iii) bind to an epitope localized on the CLD18A2-loop2, preferably SEQ ID NO: 30, (iv) bind to an epitope localized on the CLD18A2-loopD3, preferably SEQ ID NO: 31, (v) bind to an epitope, which encompass CLD18A2-loop1 and CLD18A2-loopD3, (vi) bind to a non-glycosylated epitope localized on the CLD18A2-loopD3, preferably SEQ ID NO: 29, or (vii) bind to an epitope present in human and mouse CLD18 (SEQ ID NO: 2, SEQ ID NO: 8 and SEQ ID NO: 35, SEQ ID NO: 37, respectively).

[0091] In particularly preferred embodiments, the antibodies of the teaching bind to an epitope on CLD18A2 which

is not present on CLD18A1.

[0092] Antibodies of the teaching include fully human antibodies. Such antibodies may be produced in a non-human transgenic animal, e.g., a transgenic mouse, capable of producing multiple isotypes of human monoclonal antibodies to CLD18 by undergoing V-D-J recombination and isotype switching. Such transgenic animal can also be a transgenic rabbit for producing polyclonal antibodies such as disclosed in US 2003/0017534.

[0093] Binding of an antibody of the teaching to the CLD18 antigen may mediate the killing of cells expressing CLD18 (e.g. a tumor cell), e.g. by activation of the complement system. The killing of cells expressing CLD18 may occur by one or more of the following mechanisms: complement dependent cytotoxity (CDC) of cells expressing CLD18; apoptosis of cells expressing CLD18; effector cell phagocytosis of cells expressing CLD18; or effector cell antibody dependent cellular cytotoxicity (ADCC) of cells expressing CLD18.

[0094] In order that the present teaching may be more readily understood, certain terms are first defined. Additional definitions are set forth throughout the detailed description.

DEFINITION OF TERMS

[0095] The term "CLD18" relates to claudin-18 and includes any variants, including CLD18A1 and CLD18A2, conformations, isoforms and species homologs of CLD18 which are naturally expressed by cells or are expressed by cells transfected with the CLD18 gene. Preferably, "CLD18" relates to human CLD18, in particular human CLD18A2 and/or human CLD18A1, more preferably human CLD18A2. Human CLD18A2 preferably relates to (i) a nucleic acid comprising a nucleic acid sequence encoding the amino sequence of SEQ ID NO: 2 such as a nucleic acid comprising the nucleic acid sequence of SEQ ID NO: 1 or (ii) a protein comprising the amino acid sequence of SEQ ID NO: 2, and includes any variants, conformations, isoforms and species homologs thereof which are naturally expressed by cells or are expressed by cells transfected with the CLD18A2 gene. Human CLD18A1 preferably relates to (i) a nucleic acid comprising a nucleic acid sequence encoding the amino sequence of SEQ ID NO: 8 such as a nucleic acid comprising the nucleic acid sequence of SEQ ID NO: 7 or (ii) a protein comprising the amino acid sequence of SEQ ID NO: 8, and includes any variants, conformations, isoforms and species homologs thereof which are naturally expressed by cells or are expressed by cells transfected with the CLD18A1 gene.

[0096] "Variants of CLD18" also includes a form of CLD18 consisting essentially of the extracellular domain or ectodomain of CLD18. The CLD18 "extracellular domain" or "ectodomain" refers to a form of the CLD18 polypeptide which is essentially free of the transmembrane and cytoplasmic domains. It will be understood that any transmembrane domains identified for the CLD18 polypeptides of the present teaching are identified pursuant to criteria routinely employed in the art for identifying that type of hydrophobic domain. The exact boundaries of a transmembrane domain may vary but most likely by no more than about 5 amino acids at either end of the domain as initially identified herein. Optionally, therefore, an extracellular domain of a CLD18 polypeptpide may contain from about 5 or fewer amino acids on either side of the transmembrane domain/extracellular domain boundary as identified in the examples or specification and such polypeptides, with or without the associated signal peptide, and nucleic acid encoding them, are contemplated by the present teaching.

[0097] The term "CLD18 variant" shall encompass (i) CLD18 splice variants, (ii) CLD18-posttranslationally modified variants, particularly including variants with different N-glycosylation status, (iii) CLD18 conformation variants, particularly including CLD18-conformation-1, CLD18-conformation-2 and CLD18-conformation-3, (iv) CLD18 free and homotypically/heterotypically associated variants localized at intercellular tight junctions, (v) CLD18 cancer related and CLD18 non-cancer related variants.

[0098] The term "raft" refers to the sphingolipid- and cholesterol-rich membrane microdomains located in the outer leaflet area of the plasma membrane of a cell. The ability of certain proteins to associate within such domains and their abbility of forming "aggregates" or "focal aggregates" can effect the protein's function. For

example, the translocation of CLD18 molecules into such structures, after being bound by antibodies of the present teaching, creates a high density of CLD18 antigen-antibody complexes in the plasma membranes. Such a high density of CLD18 antigen-antibody complexes can enable efficient activation of the complement system during CDC.

[0099] The terms "conformation" and "topology" describe how an integrale membrane molecule is positioned in the cell surface membrane, and, in particular, which of its regions are extracellular and thus eligible for antibodies. CLD18 for example can exist in three different conformations, which most likely depend on whether it is prevalent as homomers or heteromers and whether it is integrated in supramolecular tight junction structures or "free". These different states result in different epitopes eligible to antibodies.

[0100] According to the teaching, the term "disease" refers to any pathological state, including cancer, in particular those forms of cancer described herein. Any reference herein to cancer or particular forms of cancer also includes cancer metastasis thereof.

[0101] By "tumor" is meant an abnormal group of cells or tissue that grows by a rapid, uncontrolled cellular proliferation and continues to grow after the stimuli that initiated the new growth cease. Tumors show partial or complete lack of structural organization and functional coordination with the normal tissue, and usually form a distinct mass of tissue, which may be either benign or malignant.

[0102] By "metastasis" is meant the spread of cancer cells from its original site to another part of the body. The formation of metastasis is a very complex process and depends on detachment of malignant cells from the primary tumor, invasion of the extracellular matrix, penetration of the endothelial basement membranes to enter the body cavity and vessels, and then, after being transported by the blood, infiltration of target organs. Finally, the growth of a new tumor at the target site depends on angiogenesis. Tumor metastasis often occurs even after the removal of the primary tumor because tumor cells or components may remain and develop metastatic potential. In one embodiment, the term "metastasis" according to the teaching relates to "distant metastasis" which relates to a metastasis which is remote from the primary tumor and the regional lymph node system. In one embodiment, the term "metastasis" according to the teaching relates to lymph node metastasis. One particular form of metastasis which is treatable using the antibodies of the teaching is metastasis originating from gastric cancer as primary site. In preferred embodiments such gastric cancer metastasis is Krukenberg tumors, peritoneal metastasis and/or lymph node metastasis.

[0103] Krukenberg tumor is an uncommon metastatic tumor of the ovary accounting for 1% to 2% of all ovarian tumors. Prognosis of Krukenberg tumor is still very poor and there is no established treatment for Krukenberg tumors. Krukenberg tumor is a metastatic signet ring cell adenocarcinoma of the ovary. Stomach is the primary site in most Krukenberg tumor cases (70%). Carcinomas of colon, appendix, and breast (mainly invasive lobular carcinoma) are the next most common primary sites. Rare cases of Krukenberg tumor originating from carcinomas of the gallbladder, biliary tract, pancreas, small intestine, ampulla of Vater, cervix, and urinary bladder/urachus have been reported. The interval between the diagnosis of a primary carcinoma and the subsequent discovery of ovarian involvement is usually 6 months or less, but longer periods have been reported. In many cases, the primary tumor is very small and can escape detection. A history of a prior carcinoma of the stomach or another organ can be obtained in only 20% to 30% of the cases.

[0104] Krukenberg tumor is an example of the selective spread of cancers, most commonly in the stomach-ovarian axis. This axis of tumor spread has historically drawn the attention of many pathologists, especially when it was found that gastric neoplasms selectively metastasize to the ovaries without involvement of other tissues. The route of metastasis of gastric carcinoma to the ovaries has been a mystery for a long time, but it is now evident that retrograde lymphatic spread is the most likely route of metastasis.

[0105] Women with Krukenberg tumors tend to be unusually young for patients with metastatic carcinoma as they are typically in the fifth decade of their lives, with an average age of 45 years. This young age of distribution can be related in part to the increased frequency of gastric signet ring cell carcinomas in young women. Common

presenting symptoms are usually related to ovarian involvement, the most common of which are abdominal pain and distension (mainly because of the usually bilateral and often large ovarian masses). The remaining patients have nonspecific gastrointestinal symptoms or are asymptomatic. In addition, Krukenberg tumor is reportedly associated with virilization resulting from hormone production by ovarian stroma. Ascites is present in 50% of the cases and usually reveals malignant cells.

[0106] Krukenberg tumors are bilateral in more than 80% of the reported cases. The ovaries are usually asymmetrically enlarged, with a bosselated contour. The sectioned surfaces are yellow or white; they are usually solid, although they are occasionally cystic. Importantly, the capsular surface of the ovaries with Krukenberg tumors is typically smooth and free of adhesions or peritoneal deposits. Of note, other metastatic tumors to the ovary tend to be associated with surface implants. This may explain why the gross morphology of Krukenberg tumor can deceptively appear as a primary ovarian tumor. However, bilateralism in Krukenberg tumor is consistent with its metastatic nature.

[0107] Patients with Krukenberg tumors have an overall mortality rate that is significantly high. Most patients die within 2 years (median survival, 14 months). Several studies show that the prognosis is poor when the primary tumor is identified after the metastasis to the ovary is discovered, and the prognosis becomes worse if the primary tumor remains covert.

[0108] No optimal treatment strategy for Krukenberg tumors has been clearly established in the literature. Whether a surgical resection should be performed has not been adequately addressed. Chemotherapy or radiotherapy has no significant effect on prognosis of patients with Krukenberg tumors.

[0109] The term "treatment of a disease" includes curing, shortening the duration, ameliorating, preventing, slowing down or inhibiting progression or worsening, or preventing or delaying the onset of a disease or the symptoms thereof.

[0110] According to the teaching, a sample may be any sample useful according to the present teaching, in particular a biological sample such a tissue sample, including bodily fluids, and/or a cellular sample and may be obtained in the conventional manner such as by tissue biopsy, including punch biopsy, and by taking blood, bronchial aspirate, sputum, urine, feces or other body fluids. According to the teaching, the term "biological sample" also includes fractions of biological samples.

[0111] The term "antibody" refers to a glycoprotein comprising at least two heavy (H) chains and two light (L) chains inter-connected by disulfide bonds, or an antigen binding portion thereof. The term "antibody" also includes all recombinant forms of antibodies, in particular of the antibodies described herein, e.g., antibodies expressed in prokaryotes, unglycosylated antibodies, and any antigen-binding antibody fragments and derivatives as described below. Each heavy chain is comprised of a heavy chain variable region (abbreviated herein as VH) and a heavy chain constant region. Each light chain is comprised of a light chain variable region (abbreviated herein as VL) and a light chain constant region. The VH and VL regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each VH and VL is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. The constant regions of the antibodies may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (e.g., effector cells) and the first component (Clq) of the classical complement system.

[0112] The term "humanized antibody" refers to a molecule having an antigen binding site that is substantially derived from an immunoglobulin from a non-human species, wherein the remaining immunoglobulin structure of the molecule is based upon the structure and/or sequence of a human immunoglobulin. The antigen binding site may either comprise complete variable domains fused onto constant domains or only the complementarity determining regions (CDR) grafted onto appropriate framework regions in the variable domains. Antigen binding sites may be wild-type or modified by one or more amino acid substitutions, e.g. modified to resemble human

immunoglobulins more closely. Some forms of humanized antibodies preserve all CDR sequences (for example a humanized mouse antibody which contains all six CDRs from the mouse antibody). Other forms have one or more CDRs which are altered with respect to the original antibody.

[0113] The term "chimeric antibody" refers to those antibodies wherein one portion of each of the amino acid sequences of heavy and light chains is homologous to corresponding sequences in antibodies derived from a particular species or belonging to a particular class, while the remaining segment of the chain is homologous to corresponding sequences in another. Typically the variable region of both light and heavy chains mimics the variable regions of antibodies derived from one species of mammals, while the constant portions are homologous to sequences of antibodies derived from another. One clear advantage to such chimeric forms is that the variable region can conveniently be derived from presently known sources using readily available B-cells or hybridomas from non-human host organisms in combination with constant regions derived from, for example, human cell preparations. While the variable region has the advantage of ease of preparation and the specificity is not affected by the source, the constant region being human, is less likely to elicit an immune response from a human subject when the antibodies are injected than would the constant region from a non human source. However the definition is not limited to this particular example.

[0114] The term "antigen-binding portion" of an antibody (or simply "binding portion"), as used herein, refers to one or more fragments of an antibody that retain the ability to specifically bind to an antigen. It has been shown that the antigen-binding function of an antibody can be performed by fragments of a full-length antibody. Examples of binding fragments encompassed within the term "antigen-binding portion" of an antibody include (i) Fab fragments, monovalent fragments consisting of the VL, VH, CL and CH domains; (ii) $F(ab')_2$ fragments, bivalent fragments comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) Fd fragments consisting of the VH and CH domains; (iv) Fv fragments consisting of the VL and VH domains of a single arm of an antibody, (v) dAb fragments (Ward et al., (1989) Nature 341: 544-546), which consist of a VH domain; (vi) isolated complementarity determining regions (CDR), and (vii) combinations of two or more isolated CDRs which may optionally be joined by a synthetic linker. Furthermore, although the two domains of the Fv fragment, VL and VH, are coded for by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the VL and VH regions pair to form monovalent molecules (known as single chain Fv (scFv); see e.g., Bird et al. (1988) Science 242: 423-426; and Huston et al. (1988) Proc. Natl. Acad. Sci. USA 85: 5879-5883). Such single chain antibodies are also intended to be encompassed within the term "antigen-binding portion" of an antibody. A further example is binding-domain immunoglobulin fusion proteins comprising (i) a binding domain polypeptide that is fused to an immunoglobulin hinge region polypeptide, (ii) an immunoglobulin heavy chain CH2 constant region fused to the hinge region, and (iii) an immunoglobulin heavy chain CH3 constant region fused to the CH2 constant region. The binding domain polypeptide can be a heavy chain variable region or a light chain variable region. The binding-domain immunoglobulin fusion proteins are further disclosed in US 2003/0118592 and US 2003/0133939. These antibody fragments are obtained using conventional techniques known to those with skill in the art, and the fragments are screened for utility in the same manner as are intact antibodies.

[0115] The term "epitope" means a protein determinant capable of binding to an antibody, wherein the term "binding" herein preferably relates to a specific binding. Epitopes usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics. Conformational and non-conformational epitopes are distinguished in that the binding to the former but not the latter is lost in the presence of denaturing solvents.

[0116] The term "discontinuous epitope" as used herein, means a conformational epitope on a protein antigen which is formed from at least two separate regions in the primary sequence of the protein.

[0117] The term "bispecific molecule" is intended to include any agent, e.g., a protein, peptide, or protein or peptide complex, which has two different binding specificities. For example, the molecule may bind to, or interact with (a) a cell surface antigen, and (b) an Fc receptor on the surface of an effector cell. The term "multispecific

molecule" or "heterospecific molecule" is intended to include any agent, e.g., a protein, peptide, or protein or peptide complex, which has more than two different binding specificities. For example, the molecule may bind to, or interact with (a) a cell surface antigen, (b) an Fc receptor on the surface of an effector cell, and (c) at least one other component. Accordingly, the teaching includes, but is not limited to, bispecific, trispecific, tetraspecific, and other multispecific molecules which are directed to CLD18, and to other targets, such as Fc receptors on effector cells. The term "bispecific antibodies" also includes diabodies. Diabodies are bivalent, bispecific antibodies in which the VH and VL domains are expressed on a single polypeptide chain, but using a linker that is too short to allow for pairing between the two domains on the same chain, thereby forcing the domains to pair with complementary domains of another chain and creating two antigen binding sites (see e.g. , Holliger, P., et al. (1993) Proc. Natl. Acad. Sci. USA 90: 6444-6448; Poljak, R. J., et al. (1994) Structure 2: 1121-1123).

[0118] The teaching also includes derivatives of the antibodies described herein. The term "antibody derivatives" refers to any modified form of an antibody, e.g., a conjugate of the antibody and another agent or antibody. As used herein, an antibody is "derived from" a particular germline sequence if the antibody is obtained from a system by immunizing an animal or by screening an immunoglobulin gene library, and wherein the selected antibody is at least 90%, more preferably at least 95%, even more preferably at least 96%, 97%, 98%, or 99% identical in amino acid sequence to the amino acid sequence encoded by the germline immunoglobulin gene. Typically, an antibody derived from a particular germline sequence will display no more than 10 amino acid differences, more preferably, no more than 5, or even more preferably, no more than 4, 3, 2, or 1 amino acid difference from the amino acid sequence encoded by the germline immunoglobulin gene.

[0119] As used herein, the term "heteroantibodies" refers to two or more antibodies, derivatives thereof, or antigen binding regions linked together, at least two of which have different specificities. These different specificities include a binding specificity for an Fc receptor on an effector cell, and a binding specificity for an antigen or epitope on a target cell, e.g., a tumor cell.

[0120] The antibodies described herein may be human antibodies. The term "human antibody", as used herein, is intended to include antibodies having variable and constant regions derived from human germline immunoglobulin sequences. The human antibodies of the teaching may include amino acid residues not encoded by human germline immunoglobulin sequences (e.g., mutations introduced by random or site-specific mutagenesis in vitro or by somatic mutation in vivo).

[0121] The term "monoclonal antibody" as used herein refers to a preparation of antibody molecules of single molecular composition. A monoclonal antibody displays a single binding specificity and affinity for a particular epitope. In one embodiment, the monoclonal antibodies are produced by a hybridoma which includes a B cell obtained from a non-human animal, e.g., mouse, fused to an immortalized cell.

[0122] The term "recombinant antibody", as used herein, includes all antibodies that are prepared, expressed, created or isolated by recombinant means, such as (a) antibodies isolated from an animal (e.g., a mouse) that is transgenic or transchromosomal with respect to the immunoglobulin genes or a hybridoma prepared therefrom, (b) antibodies isolated from a host cell transformed to express the antibody, e.g., from a transfectoma, (c) antibodies isolated from a recombinant, combinatorial antibody library, and (d) antibodies prepared, expressed, created or isolated by any other means that involve splicing of immunoglobulin gene sequences to other DNA sequences.

[0123] The term "transfectoma", as used herein, includes recombinant eukaryotic host cells expressing an antibody, such as CHO cells, NS/0 cells, HEK293 cells, HEK293T cells, plant cells, or fungi, including yeast cells.

[0124] As used herein, a "heterologous antibody" is defined in relation to a transgenic organism producing such an antibody. This term refers to an antibody having an amino acid sequence or an encoding nucleic acid sequence corresponding to that found in an organism not consisting of the transgenic organism, and being generally derived from a species other than the transgenic organism.

[0125] As used herein, a "heterohybrid antibody" refers to an antibody having light and heavy chains of different organismal origins. For example, an antibody having a human heavy chain associated with a murine light chain is a heterohybrid antibody.

[0126] The antibodies described herein are preferably isolated. An "isolated antibody" as used herein, is intended to refer to an antibody which is substantially free of other antibodies having different antigenic specificities (e.g., an isolated antibody that specifically binds to CLD18 is substantially free of antibodies that specifically bind antigens other than CLD18). An isolated antibody that specifically binds to an epitope, isoform or variant of human CLD18 may, however, have cross-reactivity to other related antigens, e.g., from other species (e.g., CLD18 species homologs). Moreover, an isolated antibody may be substantially free of other cellular material and/or chemicals. In one embodiment of the teaching, a combination of "isolated" monoclonal antibodies relates to antibodies having different specificities and being combined in a well defined composition.

[0127] According to the teaching, the term "binding" preferably relates to "specific binding". As used herein, "specific binding" refers to antibody binding to a predetermined antigen. Typically, the antibody binds with an affinity corresponding to a KD of about 1×10^{-7} M or less, and binds to the predetermined antigen with an affinity corresponding to a KD that is at least two orders of magnitude lower than its affinity for binding to a non-specific antigen (e.g., BSA, casein) other than the predetermined antigen or a closely-related antigen.

[0128] The term "KD" (M), as used herein, is intended to refer to the dissociation equilibrium constant of a particular antibody-antigen interaction.

[0129] As used herein, "isotype" refers to the antibody class (e.g., IgM or IgG1) that is encoded by heavy chain constant region genes.

[0130] As used herein, "isotype switching" refers to the phenomenon by which the class, or isotype, of an antibody changes from one Ig class to one of the other Ig classes.

[0131] The term "naturally occurring" as used herein as applied to an object refers to the fact that an object can be found in nature. For example, a polypeptide or polynucleotide sequence that is present in an organism (including viruses) that can be isolated from a source in nature and which has not been intentionally modified by man in the laboratory is naturally occurring.

[0132] The term "rearranged" as used herein refers to a configuration of a heavy chain or light chain immunoglobulin locus wherein a V segment is positioned immediately adjacent to a D-J or J segment in a conformation encoding essentially a complete VH or VL domain, respectively. A rearranged immunoglobulin (antibody) gene locus can be identified by comparison to germline DNA; a rearranged locus will have at least one recombined heptamer/nonamer homology element.

[0133] The term "unrearranged" or "germline configuration" as used herein in reference to a V segment refers to the configuration wherein the V segment is not recombined so as to be immediately adjacent to a D or J segment.

[0134] The term "nucleic acid molecule", as used herein, is intended to include DNA molecules and RNA molecules. A nucleic acid molecule may be single-stranded or double-stranded, but preferably is double-stranded DNA.

[0135] The nucleic acids described according to the teaching have preferably been isolated. The term "isolated nucleic acid" means according to the teaching that the nucleic acid was (i) amplified *in vitro,* for example by polymerase chain reaction (PCR), (ii) recombinantly produced by cloning, (iii) purified, for example by cleavage and gel-electrophoretic fractionation, or (iv) synthesized, for example by chemical synthesis. An isolated nucleic acid is a nucleic acid which is available for manipulation by recombinant DNA techniques.

[0136] Nucleic acids may, according to the teaching, be present alone or in combination with other nucleic acids,

which may be homologous or heterologous. In preferred embodiments, a nucleic acid is functionally linked to expression control sequences which may be homologous or heterologous with respect to said nucleic acid. The term "homologous" means that a nucleic acid is also functionally linked to the expression control sequence naturally and the term "heterologous" means that a nucleic acid is not functionally linked to the expression control sequence naturally.

[0137] A nucleic acid, such as a nucleic acid expressing RNA and/or protein or peptide, and an expression control sequence are "functionally" linked to one another, if they are covalently linked to one another in such a way that expression or transcription of said nucleic acid is under the control or under the influence of said expression control sequence. If the nucleic acid is to be translated into a functional protein, then, with an expression control sequence functionally linked to a coding sequence, induction of said expression control sequence results in transcription of said nucleic acid, without causing a frame shift in the coding sequence or said coding sequence not being capable of being translated into the desired protein or peptide.

[0138] The term "expression control sequence" comprises according to the teaching promoters, ribosome binding sites, enhancers and other control elements which regulate transcription of a gene or translation of a mRNA. In particular embodiments of the teaching, the expression control sequences can be regulated. The exact structure of expression control sequences may vary as a function of the species or cell type, but generally comprises 5'-untranscribed and 5'- and 3'-untranslated sequences which are involved in initiation of transcription and translation, respectively, such as TATA box, capping sequence, CAAT sequence, and the like. More specifically, 5'-untranscribed expression control sequences comprise a promoter region which includes a promoter sequence for transcriptional control of the functionally linked nucleic acid. Expression control sequences may also comprise enhancer sequences or upstream activator sequences.

[0139] According to the teaching the term "promoter" or "promoter region" relates to a nucleic acid sequence which is located upstream (5') to the nucleic acid sequence being expressed and controls expression of the sequence by providing a recognition and binding site for RNA-polymerase. The "promoter region" may include further recognition and binding sites for further factors which are involved in the regulation of transcription of a gene. A promoter may control the transcription of a prokaryotic or eukaryotic gene. Furthermore, a promoter may be "inducible" and may initiate transcription in response to an inducing agent or may be "constitutive" if transcription is not controlled by an inducing agent. A gene which is under the control of an inducible promoter is not expressed or only expressed to a small extent if an inducing agent is absent. In the presence of the inducing agent the gene is switched on or the level of transcription is increased. This is mediated, in general, by binding of a specific transcription factor.

[0140] Promoters which are preferred according to the teaching include promoters for SP6, T3 and T7 polymerase, human U6 RNA promoter, CMV promoter, and artificial hybrid promoters thereof (e.g. CMV) where a part or parts are fused to a part or parts of promoters of genes of other cellular proteins such as e.g. human GAPDH (glyceraldehyde-3-phosphate dehydrogenase), and including or not including (an) additional intron(s).

[0141] According to the teaching, the term "expression" is used in its most general meaning and comprises the production of RNA or of RNA and protein/peptide. It also comprises partial expression of nucleic acids. Furthermore, expression may be carried out transiently or stably.

[0142] In a preferred embodiment, a nucleic acid molecule is according to the teaching present in a vector, where appropriate with a promoter, which controls expression of the nucleic acid. The term "vector" is used here in its most general meaning and comprises any intermediary vehicle for a nucleic acid which enables said nucleic acid, for example, to be introduced into prokaryotic and/or eukaryotic cells and, where appropriate, to be integrated into a genome. Vectors of this kind are preferably replicated and/or expressed in the cells. Vectors comprise plasmids, phagemids, bacteriophages or viral genomes. The term "plasmid" as used herein generally relates to a construct of extrachromosomal genetic material, usually a circular DNA duplex, which can replicate independently of chromosomal DNA.

[0143] As the vector for expression of an antibody, either of a vector type in which the antibody heavy chain and light chain are present in different vectors or a vector type in which the heavy chain and light chain are present in the same vector can be used.

[0144] The teaching given herein with respect to specific nucleic acid and amino acid sequences, e.g. those shown in the sequence listing, is to be construed so as to also relate to modifications of said specific sequences resulting in sequences which are functionally equivalent to said specific sequences, e.g. amino acid sequences exhibiting properties identical or similar to those of the specific amino acid sequences and nucleic acid sequences encoding amino acid sequences exhibiting properties identical or similar to those of the amino acid sequences encoded by the specific nucleic acid sequences. One important property is to retain binding of an antibody to its target or to sustain effector functions of an antibody. Preferably, a sequence modified with respect to a specific sequence, when it replaces the specific sequence in an antibody retains binding of said antibody to CLD18 and preferably functions of said antibody as described herein, e.g. CDC mediated lysis or ADCC mediated lysis.

[0145] It will be appreciated by those skilled in the art that in particular the sequences of the CDR, hypervariable and variable regions can be modified without losing the ability to bind CLD18. For example, CDR regions will be either identical or highly homologous to the regions of antibodies specified herein. By "highly homologous" it is contemplated that from 1 to 5, preferably from 1 to 4, such as 1 to 3 or 1 or 2 substitutions may be made in the CDRs. In addition, the hypervariable and variable regions may be modified so that they show substantial homology with the regions of antibodies specifically disclosed herein.

[0146] It is to be understood that the specific nucleic acids described herein also include nucleic acids modified for the sake of optimizing the codon usage in a particular host cell or organism. Differences in codon usage among organisms can lead to a variety of problems concerning heterologous gene expression. Codon optimization by changing one or more nucleotides of the original sequence can result in an optimization of the expression of a nucleic acid, in particular in optimization of translation efficacy, in a homologous or heterologous host in which said nucleic acid is to be expressed. For example if nucleic acids derived from human and encoding constant regions and/or framework regions of antibodies are to be used according to the present teaching, e.g. for preparing chimeric or humanised antibodies, it may be preferred to modify said nucleic acids for the sake of optimization of codon usage, in particular if said nucleic acids, optionally fused to heterologous nucleic acids such as nucleic acids derived from other organisms as described herein, are to be expressed in cells from an organism different from human such as mouse or hamster. For example, the nucleic acid sequences encoding human light and heavy chain constant regions such as those according to SEQ ID NOs: 40 and 45, respectively, can be modified to include one or more, preferably, at least 1, 2, 3, 4, 5, 10, 15, 20 and preferably up to 10, 15, 20, 25, 30, 50, 70 or 100 or more nucleotide replacements resulting in an optimized codon usage but not resulting in a change of the amino acid sequence. Such nucleotide replacements preferably relate to replacements of nucleotides in SEQ ID Nos: 40 and 45, respectively, selected from the replacements shown in the following alignment of SEQ ID Nos: 40 and 45, respectively, with their modified counterparts and not resulting in a change in the encoded amino acid sequence or relate to corresponding replacements at corresponding positions in other nucleic acid sequences encoding human light and heavy chain constant regions, respectively. Preferably, all of the replacements shown in the following alignments of SEQ ID Nos: 40 and 45, respectively, with their modified counterparts not resulting in a change in the encoded amino acid sequence are effected in nucleic acid sequences encoding human light and heavy chain constant regions, respectively.

[0147] Alignment of SEQ ID NO: 40 and SEQ ID NO: 147:

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CGTACGGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCT  60
||||||||||| || ||    || |||||||||| ||    || |||||| |||| ||
CGTACGGTGGCCGCTCCCAGCGTGTTCATCTTCCCCCCCAGCGACGAGCAGCTGAAGTCC  60

GGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAG  120
|| || |||   || ||||||||||||||| |||||||| ||| | |||||||| || |||
GGCACCGCCAGCGTGGTGTGCCTGCTGAACAACTTCTACCCCCGGGAGGCCAAGGTGCAG  120

TGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCACAGAGCAGGAC  180
|||||||||||| |||||||| ||    || |||  ||||||||| ||||| |||||||||
TGGAAGGTGGACAACGCCCTGCAGAGCGGCAACAGCCAGGAGAGCGTCACCGAGCAGGAC  180

AGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAG  240
|||||||||  |||||||||||| ||||||||||||||| |||||||| || |||||||||
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|||||||||  |||||||||||| |||||||||||||| |||||||| || |||||||||
AGCAAGGACTCCACCTACAGCCTGAGCAGCACCCTGACCCTGAGCAAGGCCGACTACGAG   240

AAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAG   300
|| ||||| || ||||||||||| || ||||| |||||||||  |   ||||| || |||
AAGCACAAGGTGTACGCCTGCGAGGTGACCCACCAGGGCCTGTCCAGCCCCGTGACCAAG   300

AGCTTCAACAGGGGAGAGTGTTAG   324
|||||||||||||| ||||| |||
AGCTTCAACAGGGGCGAGTGCTAG   324
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[0148] Alignment of SEQ ID NO: 45 and SEQ ID NO: 149:

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GGCCCATCGGTCTTCCCCCTGGCACCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCC   60
||||||   || ||||||||||| |||  |  ||||||||||   ||  |||||||| |||
GGCCCAAGCGTGTTCCCCCTGGCCCCCAGCAGCAAGAGCACCAGCGGCGGCACAGCCGCC   60

CTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCGTGGAACTCAGGC   120
|||||||||||||| ||||||||||||||||| || ||||| |||   ||||||   || 
CTGGGCTGCCTGGTGAAGGACTACTTCCCCGAGCCCGTGACCGTGAGCTGGAACAGCGGA   120

GCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCC   180
|||||||||  |||||||||||||||||| || || || |||  |   || || |||  |
GCCCTGACCTCCGGCGTGCACACCTTCCCCGCCGTGCTGCAGAGCAGCGGCCTGTACAGC   180

CTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACCCAGACCTACATCTGCAAC   240
|| |||||||||||||||||||||  ||||||| ||||||||||||||||||||||||||

CTGAGCAGCGTGGTGACCGTGCCCAGCAGCAGCCTGGGCACCCAGACCTACATCTGCAAC   240

GTGAATCACAAGCCCAGCAACACCAAGGTGGACAAGAAAGTTGAGCCCAAATCTTGTGAC   300
||||| ||||||||||||||||||||||||||||||| ||| ||||||||    || |||
GTGAACCACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTGGAGCCCAAGAGCTGCGAC   300

AAAACTCACACATGCCCACCGTGCCCAGCACCTGAACTCCTGGGGGGACCGTCAGTCTTC   360
|| ||| ||||| ||||| || |||||||| || || || ||||| |||||    || |||
AAGACCCACACCTGCCCCCCCTGCCCAGCCCCAGAGCTGCTGGGCGGACCCAGCGTGTTC   360

CTCTTCCCCCCAAAACCCAAGGACACCCTCATGATCTCCCGGACCCCTGAGGTCACATGC   420
|| |||||||| || |||||||||||||| ||||||  | ||||||| ||||| || |||
CTGTTCCCCCCCAAGCCCAAGGACACCCTGATGATCAGCAGGACCCCCGAGGTGACCTGC   420

GTGGTGGTGGACGTGAGCCACGAAGACCCTGAGGTCAAGTTCAACTGGTACGTGGACGGC   480
||||||||||||||||||||||| ||||| ||||| ||||||||||||||||||||||||
GTGGTGGTGGACGTGAGCCACGAGGACCCAGAGGTGAAGTTCAACTGGTACGTGGACGGC   480

GTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTACAACAGCACGTACCGT   540
||||||||||| || |||||||| |||||  | |||||||||||||||||||| ||| | 
GTGGAGGTGCACAACGCCAAGACCAAGCCCAGAGAGGAGCAGTACAACAGCACCTACAGG   540

GTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGAATGGCAAGGAGTACAAGTGC   600
|||||   ||| || ||||| |||||||||||||||||||| |||||||| |||||||||
GTGGTGTCCGTGCTGACCGTGCTGCACCAGGACTGGCTGAACGGCAAGGAATACAAGTGC   600

AAGGTCTCCAACAAAGCCCTCCCAGCCCCCATCGAGAAAACCATCTCCAAAGCCAAAGGG   660
|||||||||||||| ||||| |||||||||||||| || ||||||  ||| ||||| || 
AAGGTCTCCAACAAGGCCCTGCCAGCCCCCATCGAAAAGACCATCAGCAAGGCCAAGGGC   660

CAGCCCCGAGAACCACAGGTGTACACCCTGCCCCCATCCCGGGATGAGCTGACCAAGAAC   720
||||| || || || ||||||||||||||||||||   |||||| ||| |||||||||||
CAGCCACGGGAGCCCCAGGTGTACACCCTGCCCCCCCAGCCGGGAGGAGATGACCAAGAAC   720

CAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAGTGG   780
|||||   ||||||||| ||||| || |||||||| ||||||||||||||||||||||||
CAGGTGTCCCTGACCTGTCTGGTGAAGGGCTTCTACCCCAGCGACATCGCCGTGGAGTGG   780

GAGAGCAATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGAC   840
|||||||| || ||||| |||||||||||||||||||| || || |||||||||  ||||
GAGAGCAACGGCCAGCCCGAGAACAACTACAAGACCACCCCCCCCAGTGCTGGACAGCGAC   840

GGCTCCTTCTTCCTCTATAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCAGGGGAAC   900
|||  ||||||||| || |||||||| ||||||||||||  ||||||||||||||| |||
GGCAGCTTCTTCCTGTACAGCAAGCTGACCGTGGACAAGTCCAGGTGGCAGCAGGGCAAC   900

GTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACGCAGAAGAGCCTC   960
|| |||   |||  ||||||||| ||||| ||||||||||||||||| ||||||  ||| 
GTGTTCAGCTGCAGCGTGATGCACGAGGCCCTGCACAACCACTACACCCAGAAGTCCCTG   960

TCCCTGTCTCCGGGTAAATGA   981
  ||||   || || || |  
AGCCTGAGCCCCGGCAAGTAG   981
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[0149] Furthermore, it may be desired according to the present teaching to modify the amino acid sequences described herein, in particular those of human heavy chain constant regions to adapt the sequence to a desired allotype, e.g. an allotype found in the Caucasian population. Such modifications are preferably selected from the group consisting of the following amino acid replacments within SEQ ID NO: 46 or at corresponding positions within other human heavy chain constant regions: K93R, D235E, and L237M. Preferably, all of these modifications are included in amino acid sequences of human heavy chain constant regions.

[0150] According the teaching, the term "corresponding positions" relates to nucleotides or amino acid residues which in a sequence alignment of two nucleic acid or protein sequences are aligned to each other.

[0151] Preferably the degree of identity between a specific nucleic acid sequence described herein and a nucleic acid sequence which is modified with respect to or which is a variant of said specific nucleic acid sequence will be at least 70%, preferably at least 75%, more preferably at least 80%, even more preferably at least 90% or most preferably at least 95%, 96%, 97%, 98% or 99%. Regarding CLD18 nucleic acid variants, the degree of identity is preferably given for a region of at least about 300, at least about 400, at least about 450, at least about 500, at least about 550, at least about 600, at least about 650, at least about 700, at least about 750, or at least about 780 nucleotides. In preferred embodiments, the degree of identity is given for the entire length of the reference nucleic acid sequence, such as the nucleic acid sequences given in the sequence listing. Preferably, the two sequences are capable of hybridizing and forming a stable duplex with one another, with hybridization preferably being carried out under conditions which allow specific hybridization between polynucleotides (stringent conditions). Stringent conditions are described, for example, in Molecular Cloning: A Laboratory Manual, J. Sambrook et al., Editors, 2nd Edition, Cold Spring Harbor Laboratory press, Cold Spring Harbor, New York, 1989 or Current Protocols in Molecular Biology, F.M. Ausubel et al., Editors, John Wiley & Sons, Inc., New York and refer, for example, to hybridization at 65°C in hybridization buffer (3.5 × SSC, 0.02% Ficoll, 0.02% polyvinylpyrrolidone, 0.02% bovine serum albumin, 2.5 mM NaH_2PO_4 (pH 7), 0.5% SDS, 2 mM EDTA). SSC is 0.15 M sodium chloride/0.15 M sodium citrate, pH 7. After hybridization, the membrane to which the DNA has been transferred is washed, for example, in 2 × SSC at room temperature and then in 0.1-0.5 × SSC/0.1 × SDS at temperatures of up to 68°C.

[0152] Preferably the degree of similarity, preferably identity between a specific amino acid sequence described herein and an amino acid sequence which is modified with respect to or which is a variant of said specific amino acid sequence such as between amino acid sequences showing substantial homology will be at least 70%, preferably at least 80%, even more preferably at least 90% or most preferably at least 95%, 96%, 97%, 98% or 99%. Regarding CLD18 polypeptide variants, the degree of similarity or identity is given preferably for a region of at least about 100, at least about 120, at least about 140, at least about 160, at least about 180, at least about 200, at least about 220, at least about 240, at least about 250 or 260 amino acids. In preferred embodiments, the degree of similarity or identity is given for the entire length of the reference amino acid sequence such as the amino acid sequences given in the sequence listing.

[0153] All of the above described modified sequences or sequence variants are within the scope of the present teaching.

[0154] "Sequence similarity" indicates the percentage of amino acids that either are identical or that represent conservative amino acid substitutions. "Sequence identity" between two polypeptide or nucleic acid sequences indicates the percentage of amino acids or nucleotides that are identical between the sequences.

[0155] The "percentage identity" is obtained after the best alignment, this percentage being purely statistical and the differences between the two sequences being distributed randomly and over their entire length. Sequence comparisons between two nucleotide or amino acid sequences are conventionally carried out by comparing these sequences after having aligned them optimally, said comparison being carried out by segment or by "window of comparison" in order to identify and compare local regions of sequence similarity. The optimal alignment of the sequences for comparison may be produced, besides manually, by means of the local homology algorithm of Smith and Waterman, 1981, Ads App. Math. 2, 482, by means of the local homology algorithm of Neddleman and

Wunsch, 1970, J. Mol. Biol. 48, 443, by means of the similarity search method of Pearson and Lipman, 1988, Proc. Natl Acad. Sci. USA 85, 2444, or by means of computer programs which use these algorithms (GAP, BESTFIT, FASTA, BLAST P, BLAST N and TFASTA in Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Drive, Madison, Wis.).

[0156] The percentage identity is calculated by determining the number of identical positions between the two sequences being compared, dividing this number by the number of positions compared and multiplying the result obtained by 100 so as to obtain the percentage identity between these two sequences.

[0157] "Conservative substitutions," may be made, for instance, on the basis of similarity in polarity, charge, solubility, hydrophobicity, hydrophilicity, and/or the amphipathic nature of the residues involved. For example: (a) nonpolar (hydrophobic) amino acids include alanine, leucine, isoleucine, valine, proline, phenylalanine, tryptophan, and methionine; (b) polar neutral amino acids include glycine, serine, threonine, cysteine, tyrosine, asparagine, and glutamine; (c) positively charged (basic) amino acids include arginine, lysine, and histidine; and (d) negatively charged (acidic) amino acids include aspartic acid and glutamic acid. Substitutions typically may be made within groups (a)-(d). In addition, glycine and proline may be substituted for one another based on their ability to disrupt α-helices. Some preferred substitutions may be made among the following groups: (i) S and T; (ii) P and G; and (iii) A, V, L and I. Given the known genetic code, and recombinant and synthetic DNA techniques, the skilled scientist readily can construct DNAs encoding the conservative amino acid variants.

[0158] The present teaching comprises antibodies in which alterations have been made in the Fc region in order to change the functional or pharmacokinetic properties of the antibodies. Such alterations may result in a decrease or increase of C1q binding and CDC or of FcyR binding and ADCC. Substitutions can, for example, be made in one or more of the amino acid residues of the heavy chain constant region, thereby causing an alteration in an effector function while retaining the ability to bind to the antigen as compared with the modified antibody, cf. US 5,624,821 and US 5,648,260.

[0159] The in vivo half-life of antibodies can be improved by modifying the salvage receptor epitope of the Ig constant domain or an Ig-like constant domain such that the molecule does not comprise an intact CH2 domain or an intact Ig Fc region, cf. US 6,121,022 and US 6,194,551. The in vivo half-life can furthermore be increased by making mutations in the Fc region, e.g., by substituting threonine for leucine at position 252, by substituting threonine for serine at position 254, or by substituting threonine for phenylalanine at position 256, cf. US 6,277,375.

[0160] Furthermore, the glycosylation pattern of antibodies can be modified in order to change the effector function of the antibodies. For example, the antibodies can be expressed in a transfectoma which does not add the fucose unit normally attached to Asn at position 297 of the Fc region in order to enhance the affinity of the Fc region for Fc-Receptors which, in turn, will result in an increased ADCC of the antibodies in the presence of NK cells, cf. Shield et al. (2002) JBC, 277: 26733. Furthermore, modification of galactosylation can be made in order to modify CDC.

[0161] Alternatively, in another embodiment, mutations can be introduced randomly along all or part of a anti-CLD18 antibody coding sequence, such as by saturation mutagenesis, and the resulting modified anti-CLD18 antibodies can be screened for binding activity.

[0162] The term "recombinant host cell" (or simply "host cell"), as used herein, is intended to refer to a cell into which a recombinant expression vector has been introduced. It should be understood that such terms are intended to refer not only to the particular subject cell but to the progeny of such a cell. Because certain modifications may occur in succeeding generations due to either mutation or environmental influences, such progeny may not, in fact, be identical to the parent cell, but are still included within the scope of the term "host cell" as used herein. Recombinant host cells include, for example, transfectomas, such as CHO cells, NS/0 cells, and lymphocytic cells.

[0163] As used herein, the term "subject" includes any human or non-human animal. The term "non-human animal" includes all vertebrates, e.g., mammals and non-mammals, such as non-human primates, sheep, dog, cow, chickens, amphibians, reptiles, etc.

[0164] The terms "transgenic animal" refers to an animal having a genome comprising one or more transgenes, preferably heavy and/or light chain transgenes, or transchromosomes (either integrated or non-integrated into the animal's natural genomic DNA) and which is preferably capable of expressing the transgenes. For example, a transgenic mouse can have a human light chain transgene and either a human heavy chain transgene or human heavy chain transchromosome, such that the mouse produces human anti-CLD18 antibodies when immunized with CLD18 antigen and/or cells expressing CLD18. The human heavy chain transgene can be integrated into the chromosomal DNA of the mouse, as is the case for transgenic mice, e.g., HuMAb mice, such as HCo7 or HCol2 mice, or the human heavy chain transgene can be maintained extrachromosomally, as is the case for transchromosomal (e.g., KM) mice as described in WO 02/43478. Such transgenic and transchromosomal mice may be capable of producing multiple isotypes of human monoclonal antibodies to CLD18 (e.g., IgG, IgA and/or IgE) by undergoing V-D-J recombination and isotype switching.

[0165] "Reduce" or "inhibit" as used herein means the ability to cause an overall decrease, preferably of 5% or greater, 10% or greater, 20% or greater, more preferably of 50% or greater, and most preferably of 75% or greater, in the level, e.g. in the level of proliferation of cells.

Mechanisms of mAb action

[0166] Although the following provides considerations regarding the mechanism underlying the therapeutic efficacy of antibodies of the teaching it is not to be considered as limiting to the teaching in any way.

[0167] The antibodies described herein preferably interact with components of the immune system, preferably through ADCC or CDC. Antibodies of the teaching can also be used to target payloads (e.g., radioisotopes, drugs or toxins) to directly kill tumor cells or can be used synergistically with traditional chemotherapeutic agents, attacking tumors through complementary mechanisms of action that may include anti-tumor immune responses that may have been compromised owing to a chemotherapeutic's cytotoxic side effects on T lymphocytes. However, antibodies of the teaching may also exert an effect simply by binding to CLD18 on the cell surface, thus, e.g. blocking proliferation of the cells.

Antibody-dependent cell-mediated cytotoxicity

[0168] ADCC describes the cell-killing ability of effector cells as described herein, in particular lymphocytes, which preferably requires the target cell being marked by an antibody.

[0169] ADCC preferably occurs when antibodies bind to antigens on tumor cells and the antibody Fc domains engage Fc receptors (FcR) on the surface of immune effector cells. Several families of Fc receptors have been identified, and specific cell populations characteristically express defined Fc receptors. ADCC can be viewed as a mechanism to directly induce a variable degree of immediate tumor destruction that leads to antigen presentation and the induction of tumor-directed T-cell responses. Preferably, *in vivo* induction of ADCC will lead to tumor-directed T-cell responses and host-derived antibody responses.

Complement-dependent cytotoxicity

[0170] CDC is another cell-killing method that can be directed by antibodies. IgM is the most effective isotype for complement activation. IgG1 and IgG3 are also both very effective at directing CDC via the classical complement-

activation pathway. Preferably, in this cascade, the formation of antigen-antibody complexes results in the uncloaking of multiple C1q binding sites in close proximity on the C_H2 domains of participating antibody molecules such as IgG molecules (C1q is one of three subcomponents of complement C1). Preferably these uncloaked C1q binding sites convert the previously low-affinity C1q-IgG interaction to one of high avidity, which triggers a cascade of events involving a series of other complement proteins and leads to the proteolytic release of the effector-cell chemotactic/activating agents C3a and C5a. Preferably, the complement cascade ends in the formation of a membrane attack complex, which creates pores in the cell membrane that facilitate free passage of water and solutes into and out of the cell.

Production of antibodies

[0171] Antibodies of the teaching can be produced by a variety of techniques, including conventional monoclonal antibody methodology, e.g., the standard somatic cell hybridization technique of Kohler and Milstein, Nature 256: 495 (1975). Although somatic cell hybridization procedures are preferred, in principle, other techniques for producing monoclonal antibodies can be employed, e.g., viral or oncogenic transformation of B-lymphocytes or phage display techniques using libraries of antibody genes.

[0172] The preferred animal system for preparing hybridomas that secrete monoclonal antibodies is the murine system. Hybridoma production in the mouse is a very well established procedure. Immunization protocols and techniques for isolation of immunized splenocytes for fusion are known in the art. Fusion partners (e.g., murine myeloma cells) and fusion procedures are also known.

[0173] Other preferred animal systems for preparing hybridomas that secrete monoclonal antibodies are the rat and the rabbit system (e.g. described in Spieker-Polet et al., Proc. Natl. Acad. Sci. U.S.A. 92:9348 (1995), see also Rossi et al., Am. J. Clin. Pathol. 124: 295 (2005)).

[0174] In yet another preferred embodiment, human monoclonal antibodies directed against CLD18 can be generated using transgenic or transchromosomal mice carrying parts of the human immune system rather than the mouse system. These transgenic and transchromosomic mice include mice known as HuMAb mice and KM mice, respectively, and are collectively referred to herein as "transgenic mice." The production of human antibodies in such transgenic mice can be performed as described in detail for CD20 in WO2004 035607

[0175] Yet another strategy for generating monoclonal antibodies is to directly isolate genes encoding antibodies from lymphocytes producing antibodies of defined strategy e.g. see Babcock et al., 1996; A novel strategy for generating monoclonal antibodies from single, isolated lymphocytes producing antibodies of defined strategy. For details of recombinant antibody engineering see also Welschof and Kraus, Recombinant antibodes for cancer therapy ISBN-0-89603-918-8 and Benny K.C. Lo Antibody Engineering ISBN 1-58829-092-1.

Immunizations

[0176] To generate antibodies to CLD18, mice can be immunized with carrier-conjugated peptides derived from the CLD18 sequence, an enriched preparation of recombinantly expressed CLD18 antigen or fragments thereof and/or cells expressing CLD18, as described. Alternatively, mice can be immunized with DNA encoding full length human CLD18 (e.g. SEQ ID NO: 1) or fragments thereof, in particular those of SEQ ID Nos:15, 17, and 19. In the event that immunizations using a purified or enriched preparation of the CLD18 antigen do not result in antibodies, mice can also be immunized with cells expressing CLD18, e.g., a cell line, to promote immune responses.

[0177] The immune response can be monitored over the course of the immunization protocol with plasma and serum samples being obtained by tail vein or retroorbital bleeds. Mice with sufficient titers of anti-CLD18 immunoglobulin can be used for fusions. Mice can be boosted intraperitonealy or intravenously with CLD18

expressing cells 3 days before sacrifice and removal of the spleen to increase the rate of specific antibody secreting hybridomas.

Generation of Hybridomas Producing Monoclonal Antibodies

[0178] To generate hybridomas producing monoclonal antibodies to CLD18, splenocytes and lymph node cells from immunized mice can be isolated and fused to an appropriate immortalized cell line, such as a mouse myeloma cell line. The resulting hybridomas can then be screened for the production of antigen-specific antibodies. Individual wells can then be screened by ELISA for antibody secreting hybridomas. By Immunofluorescence and FACS analysis using CLD18 expressing cells, antibodies with specificity for CLD18 can be identified. The antibody secreting hybridomas can be replated, screened again, and if still positive for anti-CLD18 monoclonal antibodies can be subcloned by limiting dilution. The stable subclones can then be cultured in vitro to generate antibody in tissue culture medium for characterization.

Generation of Transfectomas Producing Monoclonal Antibodies

[0179] Antibodies of the teaching also can be produced in a host cell transfectoma using, for example, a combination of recombinant DNA techniques and gene transfection methods as are well known in the art (Morrison, S. (1985) Science 229: 1202).

[0180] For example, in one embodiment, the gene(s) of interest, e.g., antibody genes, can be ligated into an expression vector such as a eukaryotic expression plasmid such as used by the GS gene expression system disclosed in WO 87/04462, WO 89/01036 and EP 338 841 or other expression systems well known in the art. The purified plasmid with the cloned antibody genes can be introduced in eukaryotic host cells such as CHO cells, NS/0 cells, HEK293T cells or HEK293 cells or alternatively other eukaryotic cells like plant derived cells, fungal or yeast cells. The method used to introduce these genes can be methods described in the art such as electroporation, lipofectine, lipofectamine or others. After introduction of these antibody genes in the host cells, cells expressing the antibody can be identified and selected. These cells represent the transfectomas which can then be amplified for their expression level and upscaled to produce antibodies. Recombinant antibodies can be isolated and purified from these culture supernatants and/or cells. Alternatively, the cloned antibody genes can be expressed in other expression systems, including prokaryotic cells, such as microorganisms, e.g. E. coli. Furthermore, the antibodies can be produced in transgenic non-human animals, such as in milk from sheep and rabbits or in eggs from hens, or in transgenic plants; see e.g. Verma, R., et al. (1998) J. Immunol. Meth. 216: 165-181; Pollock, et al. (1999) J. Immunol. Meth. 231: 147-157; and Fischer, R., et al. (1999) Biol. Chem. 380: 825-839.

Use of Partial Antibody Sequences to Express Intact Antibodies (i.e. humanization and chimerisation).

a) Chimerization

[0181] Murine monoclonal antibodies can be used as therapeutic antibodies in humans when labeled with toxins or radioactive isotopes. Nonlabeled murine antibodies are highly immunogenic in man when repetitively applied leading to reduction of the therapeutic effect. The main immunogenicity is mediated by the heavy chain constant regions. The immunogenicity of murine antibodies in man can be reduced or completely avoided if respective antibodies are chimerized or humanized.

[0182] Chimeric antibodies are antibodies, the different portions of which are derived from different animal species, such as those having a variable region derived from a murine antibody and a human immunoglobulin

constant region. Chimerisation of antibodies is achieved by joining of the variable regions of the murine antibody heavy and light chain with the constant region of human heavy and light chain (e.g. as described by Kraus et al., in Methods in Molecular Biology series, Recombinant antibodies for cancer therapy ISBN-0-89603-918-8). In a preferred embodiment chimeric antibodies are generated by joining human kappa-light chain constant region to murine light chain variable region. In an also preferred embodiment chimeric antibodies can be generated by joining human lambda-light chain constant region to murine light chain variable region. The preferred heavy chain constant regions for generation of chimeric antibodies are IgG1, IgG3 and IgG4. Other preferred heavy chain constant regions for generation of chimeric antibodies are IgG2, IgA, IgD and IgM.

b) Humanization

[0183] Antibodies interact with target antigens predominantly through amino acid residues that are located in the six heavy and light chain complementarity determining regions (CDRs). For this reason, the amino acid sequences within CDRs are more diverse between individual antibodies than sequences outside of CDRs. Because CDR sequences are responsible for most antibody-antigen interactions, it is possible to express recombinant antibodies that mimic the properties of specific naturally occurring antibodies by constructing expression vectors that include CDR sequences from the specific naturally occurring antibody grafted onto framework sequences from a different antibody with different properties (see, e.g., Riechmann, L. et al. (1998) Nature 332: 323-327; Jones, P. et al. (1986) Nature 321: 522-525; and Queen, C. et al. (1989) Proc. Natl. Acad. Sci. U. S. A. 86: 10029-10033). Such framework sequences can be obtained from public DNA databases that include germline antibody gene sequences. These germline sequences will differ from mature antibody gene sequences because they will not include completely assembled variable genes, which are formed by V (D) J joining during B cell maturation. Germline gene sequences will also differ from the sequences of a high affinity secondary repertoire antibody at individual evenly across the variable region. For example, somatic mutations are relatively infrequent in the amino terminal portion of framework region 1 and in the carboxy-terminal portion of framework region 4. Furthermore, many somatic mutations do not significantly alter the binding properties of the antibody. For this reason, it is not necessary to obtain the entire DNA sequence of a particular antibody in order to recreate an intact recombinant antibody having binding properties similar to those of the original antibody (see WO 99/45962). Partial heavy and light chain sequences spanning the CDR regions are typically sufficient for this purpose. The partial sequence is used to determine which germline variable and joining gene segments contributed to the recombined antibody variable genes. The germline sequence is then used to fill in missing portions of the variable regions. Heavy and light chain leader sequences are cleaved during protein maturation and do not contribute to the properties of the final antibody. To add missing sequences, cloned cDNA sequences can be combined with synthetic oligonucleotides by ligation or PCR amplification. Alternatively, the entire variable region can be synthesized as a set of short, overlapping, oligonucleotides and combined by PCR amplification to create an entirely synthetic variable region clone. This process has certain advantages such as elimination or inclusion or particular restriction sites, or optimization of particular codons.

[0184] The nucleotide sequences of heavy and light chain transcripts from hybridomas are used to design an overlapping set of synthetic oligonucleotides to create synthetic V sequences with identical amino acid coding capacities as the natural sequences. The synthetic heavy and kappa chain sequences can differ from the natural sequences in three ways: strings of repeated nucleotide bases are interrupted to facilitate oligonucleotide synthesis and PCR amplification; optimal translation initiation sites are incorporated according to Kozak's rules (Kozak, 1991, J. Biol. Chem. 266: 19867-19870); and HindIII sites are engineered upstream of the translation initiation sites.

[0185] For both the heavy and light chain variable regions, the optimized coding and corresponding non-coding, strand sequences are broken down into 30-50 nucleotides approximately at the midpoint of the corresponding non-coding oligonucleotide. Thus, for each chain, the oligonucleotides can be assembled into overlapping double stranded sets that span segments of 150-400 nucleotides. The pools are then used as templates to produce PCR amplification products of 150-400 nucleotides. Typically, a single variable region oligonucleotide set will be broken down into two pools which are separately amplified to generate two overlapping PCR products. These overlapping

products are then combined by PCR amplification to form the complete variable region. It may also be desirable to include an overlapping fragment of the heavy or light chain constant region in the PCR amplification to generate fragments that can easily be cloned into the expression vector constructs.

[0186] The reconstructed chimerized or humanized heavy and light chain variable regions are then combined with cloned promoter, leader, translation initiation, constant region, 3' untranslated, polyadenylation, and transcription termination sequences to form expression vector constructs. The heavy and light chain expression constructs can be combined into a single vector, co-transfected, serially transfected, or separately transfected into host cells which are then fused to form a host cell expressing both chains. Plasmids for use in construction of expression vectors for human IgGκ are described below. The plasmids were constructed so that PCR amplified V heavy and V kappa light chain cDNA sequences could be used to reconstruct complete heavy and light chain minigenes. These plasmids can be used to express completely human, or chimeric IgG1, Kappa or IgG4, Kappa antibodies. Similar plasmids can be constructed for expression of other heavy chain isotypes, or for expression of antibodies comprising lambda light chains.

[0187] Thus, in another aspect of the teaching, the structural features of the anti-CLD18 antibodies of the teaching, are used to create structurally related humanized anti-CLD18 antibodies that retain at least one functional property of the antibodies of the teaching, such as binding to CLD18. More specifically, one or more CDR regions of mouse monoclonal antibodies can be combined recombinantly with known human framework regions and CDRs to create additional, recombinantly-engineered, humanized anti-CLD18 antibodies of the teaching.

Binding to antigen expressing cells

[0188] The ability of the antibody to bind CLD18 can be determined using standard binding assays, such as those set forth in the examples (e.g., ELISA, Western Blot, Immunofluorescence and flow cytometric analysis)

Characterization of binding of antibodies

[0189] To purify anti-CLD18 antibodies, selected hybridomas can be grown in two-liter spinner-flasks for monoclonal antibody purification. Alternatively, anti-CLD18 antibodies can be produced in dialysis based bioreactors. Supernatants can be filtered and, if necessary, concentrated before affinity chromatography with protein G-sepharose or protein A-sepharose. Eluted IgG can be checked by gel electrophoresis and high performance liquid chromatography to ensure purity. The buffer solution can be exchanged into PBS, and the concentration can be determined by OD280 using 1.43 extinction coefficient. The monoclonal antibodies can be aliquoted and stored at -80°C.

[0190] To determine if the selected anti-CLD18 monoclonal antibodies bind to unique epitopes, site-directed or multi-site directed mutagenesis can be used.

Isotype determination

[0191] To determine the isotype of purified antibodies, isotype ELISAs with various commercial kits (e.g. Zymed, Roche Diagnostics) can be performed. Wells of microtiter plates can be coated with anti-mouse Ig. After blocking, the plates are reacted with monoclonal antibodies or purified isotype controls, at ambient temperature for two hours. The wells can then be reacted with either mouse IgG1, IgG2a, IgG2b or IgG3, IgA or mouse IgM-specific peroxidase-conjugated probes. After washing, the plates can be developed with ABTS substrate (1 mg/ml) and analyzed at OD of 405-650. Alternatively, the IsoStrip Mouse Monoclonal Antibody Isotyping Kit (Roche, Cat. No. 1493027) may be used as described by the manufacturer.

Flow cytometric analysis

[0192] In order to demonstrate presence of anti-CLD18 antibodies in sera of immunized mice or binding of monoclonal antibodies to living cells expressing CLD18, flow cytometry can be used. Cell lines expressing naturally or after transfection CLD18 and negative controls lacking CLD18 expression (grown under standard growth conditions) can be mixed with various concentrations of monoclonal antibodies in hybridoma supernatants or in PBS containing 1% FBS, and can be incubated at 4°C for 30 min. After washing, the APC- or Alexa647-labeled anti IgG antibody can bind to CLD18-bound monoclonal antibody under the same conditions as the primary antibody staining. The samples can be analyzed by flow cytometry with a FACS instrument using light and side scatter properties to gate on single, living cells. In order to distinguish CLD18-specific monoclonal antibodies from non-specific binders in a single measurement, the method of co-transfection can be employed. Cells transiently transfected with plasmids encoding CLD18 and a fluorescent marker can be stained as described above. Transfected cells can be detected in a different fluorescence channel than antibody-stained cells. As the majority of transfected cells express both transgenes, CLD18-specific monoclonal antbodies bind preferentially to fluorescence marker expressing cells, whereas non-specific antibodies bind in a comparable ratio to non-transfected cells. An alternative assay using fluorescence microscopy may be used in addition to or instead of the flow cytometry assay. Cells can be stained exactly as described above and examined by fluorescence microscopy.

[0193] Tight junction proteins tend to be internalized, if cell cell contact to neighbouring cells of particularly adherent cells is lost by e.g. detachment of cells. Cell surface expression of CLD18 can be optimized by a) adjusting culture conditions, e.g. culturing in higher cell densitiy in a standardized manner, using mild detachment (e.g. 2mM EDTA/PBS or accutase), processing at room temperature, and adding inhibitors of endocytosis (e.g. sodium azide) or activators of CLD18 transcription or translation, and by b) selecting and cloning of cells maintaining CLD18 in high levels at the cell surface, e.g. by selection with antibiotics in terms of transfected cells, by immunomagnetic or FACS cell sorting, and by limited dilution cloning.

Immunofluorescence microscopy

[0194] In order to demonstrate presence of anti-CLD18 antibodies in sera of immunized mice or binding of monoclonal antibodies to living cells expressing CLD18, immunofluorescence microscopy analysis can be used. For example, cell lines expressing either spontaneously or after transfection CLD18 and negative controls lacking CLD18 expression are grown in chamber slides under standard growth conditions in DMEM/F12 medium, supplemented with 10 % fetal calf serum (FCS), 2 mM L-glutamine, 100 IU/ml penicillin and 100 µg/ml streptomycin. Cells can then be fixed with methanol or paraformaldehyde or left untreated. Cells can then be reacted with monoclonal antibodies against CLD18 for 30 min. at 25°C. After washing, cells can be reacted with an Alexa555-labelled anti-mouse IgG secondary antibody (Molecular Probes) under the same conditions. Cells can then be examined by fluorescence microscopy.

[0195] Total CLD18 levels in cells can be observed when cells are methanol fixed or paraformaldehyde fixed and permeabilized with Triton X-100. In living cells and non-permeabilized, paraformaldehyde fixed cells surface localization of CLD18 can be examined. Additionally targeting of CLD18 to tight junctions can be analyzed by co-staining with tight junction markers such as ZO-1. Furthermore, effects of antibody binding and CLD18 localization within the cell membrane can be examined.

Western Blot

[0196] Anti-CLD18 IgG can be further tested for reactivity with CLD18 antigen by Western Blotting. Briefly, cell extracts from cells expressing CLD18 and appropriate negative controls can be prepared and subjected to sodium

dodecyl sulfate (SDS) polyacrylamide gel electrophoresis. After electrophoresis, the separated antigens will be transferred to nitrocellulose membranes, blocked, and probed with the monoclonal antibodies to be tested. IgG binding can be detected using anti-mouse IgG peroxidase and developed with ECL substrate.

Immunohistochemistry

[0197] Anti-CLD18 mouse IgGs can be further tested for reactivity with CLD18 antigen by Immunohistochemistry in a manner well known to the skilled person, e.g. using paraformaldehyde or acetone fixed cryosections or paraffin embedded tissue sections fixed with paraformaldehyde from non-cancer tissue or cancer tissue samples obtained from patients during routine surgical procedures or from mice carrying xenografted tumors inoculated with cell lines expressing spontaneously (e.g. DAN-G, SNU-16, or KATO-III) or after transfection (e.g. HEK293) CLD18. For immunostaining antibodies reactive to CLD18 can be incubated followed by horseradish-peroxidase conjugated goat anti-mouse or goat anti-rabbit antibodies (DAKO) according to the vendors instructions.

Phagocytic and Cell Killing Activities of Antibodies in vitro

[0198] In addition to binding specifically to CLD18, anti-CLD18 antibodies can be tested for their ability to mediate phagocytosis and killing of cells expressing CLD18. The testing of monoclonal antibody activity in vitro will provide an initial screening prior to testing in vivo models.

Antibody dependent cell-mediated cytotoxicity (ADCC):

[0199] Briefly, polymorphonuclear cells (PMNs), NK cells, monocytes, mononuclear cells or other effector cells, from healthy donors can be purified by Ficoll Hypaque density centrifugation, followed by lysis of contaminating erythrocytes. Washed effector cells can be suspended in RPMI supplemented with 10% heat-inactivated fetal calf serum or, alternatively with 5% heat-inactivated human serum and mixed with ^{51}Cr labeled target cells expressing CLD18, at various ratios of effector cells to target cells. Alternatively, the target cells may be labeled with a fluorescence enhancing ligand (BATDA). A highly fluorescent chelate of Europium with the enhancing ligand which is released from dead cells can be measured by a fluorometer. Another alternative technique may utilize the transfection of target cells with luciferase. Added lucifer yellow may then be oxidated by viable cells only. Purified anti-CLD18 IgGs can then be added at various concentrations. Irrelevant human IgG can be used as negative control. Assays can be carried out for 4 to 20 hours at 37°C depending on the effector cell type used. Samples can be assayed for cytolysis by measuring ^{51}Cr release or the presence of the EuTDA chelate in the culture supernatant. Alternatively, luminescence resulting from the oxidation of lucifer yellow can be a measure of viable cells.

[0200] Anti-CLD18 monoclonal antibodies can also be tested in various combinations to determine whether cytolysis is enhanced with multiple monoclonal antibodies.

Complement dependent cytotoxicity (CDC):

[0201] Monoclonal anti-CLD18 antibodies can be tested for their ability to mediate CDC using a variety of known techniques. For example, serum for complement can be obtained from blood in a manner known to the skilled person. To determine the CDC activity of mAbs, different methods can be used. ^{51}Cr release can for example be measured or elevated membrane permeability can be assessed using a propidium iodide (PI) exclusion assay. Briefly, target cells can be washed and 5×10^5/ml can be incubated with various concentrations of mAb for 10-30 min. at room temperature or at 37°C. Serum or plasma can then be added to a final concentration of 20% (v/v)

and the cells incubated at 37°C for 20-30 min. All cells from each sample can be added to the PI solution in a FACS tube. The mixture can then be analyzed immediately by flow cytometry analysis using FACSArray.

[0202] In an alternative assay, induction of CDC can be determined on adherent cells. In one embodiment of this assay, cells are seeded 24 h before the assay with a density of 3×10^4/well in tissue-culture flat-bottom microtiter plates. The next day growth medium is removed and the cells are incubated in triplicates with antibodies. Control cells are incubated with growth medium or growth medium containing 0.2% saponin for the determination of background lysis and maximal lysis, respectively. After incubation for 20 min. at room temperature supernatant is removed and 20% (v/v) human plasma or serum in DMEM (prewarmed to 37°C) is added to the cells and incubated for another 20 min. at 37°C. All cells from each sample are added to propidium iodide solution (10 µg/ml). Then, supernatants are replaced by PBS containing 2.5 µg/ml ethidium bromide and fluorescence emission upon excitation at 520 nm is measured at 600 nm using a Tecan Safire. The percentage specific lysis is calculated as follows: % specific lysis = (fluorescence sample-fluorescence background)/ (fluorescence maximal lysis-fluorescence background) × 100.

Inhibition of cell proliferation by monoclonal antibodies:

[0203] To test for the ability to initiate apoptosis, monoclonal anti-CLD18 antibodies can, for example, be incubated with CLD18 positive tumor cells, e.g., SNU-16, DAN-G, KATO-III or CLD18 transfected tumor cells at 37°C for about 20 hours. The cells can be harvested, washed in Annexin-V binding buffer (BD biosciences), and incubated with Annexin V conjugated withFITC or APC (BD biosciences) for 15 min. in the dark. All cells from each sample can be added to PI solution (10 µg/ml in PBS) in a FACS tube and assessed immediately by flow cytometry (as above). Alternatively, a general inhibition of cell-proliferation by monoclonal antibodies can be detected with commercially available kits. The DELFIA Cell Proliferation Kit (Perkin-Elmer, Cat. No. AD0200) is a non-isotopic immunoassay based on the measurement of 5-bromo-2'-deoxyuridine (BrdU) incorporation during DNA synthesis of proliferating cells in microplates. Incorporated BrdU is detected using europium labelled monoclonal antibody. To allow antibody detection, cells are fixed and DNA denatured using Fix solution. Unbound antibody is washed away and DELFIA inducer is added to dissociate europium ions from the labelled antibody into solution, where they form highly fluorescent chelates with components of the DELFIA Inducer. The fluorescence measured - utilizing time-resolved fluorometry in the detection - is proportional to the DNA synthesis in the cell of each well.

Preclinical studies

[0204] Monoclonal antibodies which bind to CLD18 also can be tested in an in vivo model (e.g. in immune deficient mice carrying xenografted tumors inoculated with cell lines expressing CLD18, e.g. DAN-G, SNU-16, or KATO-III, or after transfection, e.g. HEK293) to determine their efficacy in controlling growth of CLD18-expressing tumor cells.

[0205] In vivo studies after xenografting CLD18 expressing tumor cells into immunocompromised mice or other animals can be performed using antibodies of the teaching. Antibodies can be adminstered to tumor free mice followed by injection of tumor cells to measure the effects of the antibodies to prevent formation of tumors or tumor-related symptoms. Antibodies can be adminstered to tumor-bearing mice to determine the therapeutic efficacy of respective antibodies to reduce tumor growth, metastasis or tumor related symptoms. Antibody application can be combined with application of other substances as cystostatic drugs, growth factor inhibitors, cell cycle blockers, angiogenesis inhibitors or other antibodies to determine synergistic efficacy and potential toxicity of combinations.

[0206] To analyze toxic side effects mediated by antibodies of the teaching animals can be inoculated with antibodies or control reagents and thoroughly investigated for symptoms possibly related to CLD18-antibody

therapy. Possible side effects of in vivo application of CLD18 antibodies particularly include toxicity at CLD18 expressing tissues including stomach and lung. Antibodies recognizing CLD18 in human and in other species, e.g. mice, are particularly useful to predict potential side effects mediated by application of monoclonal CLD18-antibodies in humans.

Epitope mapping

[0207] Mapping of epitopes recognized by antibodies of teaching can be performed as described in detail in "Epitope Mapping Protocols (Methods in Molecular Biology) by Glenn E. Morris ISBN-089603-375-9 and in "Epitope Mapping: A Practical Approach" Practical Approach Series, 248 by Olwyn M. R. Westwood, Frank C. Hay.

I. Bispecific/Multispecific Molecules Which Bind to CLD18

[0208] In yet another embodiment of the teaching, antibodies to CLD18 can be derivatized or linked to another functional molecule, e.g., another peptide or protein (e.g., an Fab' fragment) to generate a bispecific or multispecific molecule which binds to multiple binding sites or target epitopes. For example, an antibody of the teaching can be functionally linked (e.g. by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other binding molecules, such as another antibody, peptide or binding mimetic.

[0209] Accordingly, the present teaching includes bispecific and multispecific molecules comprising at least one first binding specificity for CLD18 and a second binding specificity for a second target epitope. In a particular embodiment of the teaching, the second target epitope is an Fc receptor, e.g. human Fc-gammaRI (CD64) or a human Fc-alpha receptor (CD89), or a T cell receptor, e.g. CD3. Therefore, the teaching includes bispecific and multispecific molecules capable of binding both to Fc-gammaR, Fc-alphaR or Fc-epsilonR expressing effector cells (e.g. monocytes, macrophagesor polymorphonuclear cells (PMNs)), and to target cells expressing CLD18. These bispecific and multispecific molecules may target CLD18 expressing cells to effector cell and may trigger Fc receptor-mediated effector cell activities, such as phagocytosis of CLD18 expressing cells, antibody dependent cellular cytotoxicity (ADCC), cytokine release, or generation of superoxide anion.

[0210] Bispecific and multispecific molecules of the teaching can further include a third binding specificity, in addition to an anti-Fc binding specificity and an anti-CLD18 binding specificity. In one embodiment, the third binding specificity is an anti-enhancement factor (EF) portion, e.g. a molecule which binds to a surface protein involved in cytotoxic activity and thereby increases the immune response against the target cell. The "anti-enhancement factor portion" can be an antibody, functional antibody fragment or a ligand that binds to a given molecule, e.g., an antigen or a receptor, and thereby results in an enhancement of the effect of the binding determinants for the Fc receptor or target cell antigen. The "anti-enhancement factor portion" can bind an Fc receptor or a target cell antigen. Alternatively, the anti-enhancement factor portion can bind to an entity that is different from the entity to which the first and second binding specificities bind. For example, the anti-enhancement factor portion can bind a cytotoxic T cell (e.g., via CD2, CD3, CD8, CD28, CD4, CD40, ICAM-1 or other immune cell that results in an increased immune response against the target cell).

[0211] In one embodiment, the bispecific and multispecific molecules of the teaching comprise as a binding specificity at least one antibody, including, e.g., an Fab, Fab', $F(ab')_2$, Fv, or a single chain Fv. The antibody may also be a light chain or heavy chain dimer, or any minimal fragment thereof such as a Fv or a single chain construct as described in Ladner et al., US 4,946,778. The antibody may also be a binding-domain immunoglobulin fusion protein as disclosed in US2003/0118592 and US 2003/0133939.

[0212] In one embodiment bispecific and multispecific molecules of the teaching comprise a binding specificity for an Fc-gammaR or an Fc-alphaR present on the surface of an effector cell, and a second binding specificity for a target cell antigen, e.g., CLD18.

[0213] In one embodiment, the binding specificity for an Fc receptor is provided by a monoclonal antibody, the binding of which is not blocked by human immunoglobulin G (IgG). As used herein, the term "IgG receptor" refers to any of the eight gamma-chain genes located on chromosome 1. These genes encode a total of twelve transmembrane or soluble receptor isoforms which are grouped into three Fc-gamma receptor classes: Fc-gammaRI (CD64), Fc-gammaRII (CD32), and Fc-gammaRIII (CD16). In one preferred embodiment, the Fc-gamma receptor is a human high affinity Fc-gammaRI.

[0214] The production and characterization of these preferred monoclonal antibodies are described by Fanger et al. in WO 88/00052 and in US 4,954,617. These antibodies bind to an epitope of Fc-gammaRI, Fc-gammaRII or Fc-gammayRIII at a site which is distinct from the Fcy binding site of the receptor and, thus, their binding is not blocked substantially by physiological levels of IgG. Specific anti-Fc-gammaRI antibodies useful in this teaching are mAb 22, mAb 32, mAb 44, mAb 62 and mAb 197. In other embodiments, the anti-Fcy receptor antibody is a humanized form of monoclonal antibody 22 (H22). The production and characterization of the H22 antibody is described in Graziano, R. F. et al. (1995) J. Immunol. 155 (10): 4996-5002 and WO 94/10332. The H22 antibody producing cell line was deposited at the American Type Culture Collection on November 4, 1992 under the designation HA022CL1 and has the accession No. CRL 11177.

[0215] In still other preferred embodiments, the binding specificity for an Fc receptor is provided by an antibody that binds to a human IgA receptor, e.g., an Fc-alpha receptor (Fc-alphaRI (CD89)), the binding of which is preferably not blocked by human immunoglobulin A (IgA). The term "IgA receptor" is intended to include the gene product of one alpha-gene (Fc-alphaRI) located on chromosome 19. This gene is known to encode several alternatively spliced transmembrane isoforms of 55 to 110 kDa. Fc-alphaRI (CD89) is constitutively expressed on monocytes/macrophages, eosinophilic and neutrophilic granulocytes, but not on non-effector cell populations. Fc-alphaRI has medium affinity for both IgA1 and IgA2, which is increased upon exposure to cytokines such as G-CSF or GM-CSF (Morton, H. C. et al. (1996) Critical Reviews in Immunology 16: 423-440). Four Fc-alphaRI-specific monoclonal antibodies, identified as A3, A59, A62 and A77, which bind Fc-alphaRI outside the IgA ligand binding domain, have been described (Monteiro, R. C. et al. (1992) J.Immunol. 148: 1764).

[0216] Fc-alphaRI and Fc-gammaRI are preferred trigger receptors for use in the teaching because they (1) are expressed primarily on immune effector cells, e.g., monocytes, PMNs, macrophages and dendritic cells; (2) are expressed at high levels (e.g., 5,000-100,000 per cell); (3) are mediators of cytotoxic activities (e.g., ADCC, phagocytosis); (4) mediate enhanced antigen presentation of antigens, including self-antigens, targeted to them.

[0217] In another embodiment the bispecific molecule is comprised of two monoclonal antibodies according to the teaching which have complementary functional activities, such as one antibody predominately working by inducing CDC and the other antibody predominately working by inducing apoptosis.

[0218] An "effector cell specific antibody" as used herein refers to an antibody or functional antibody fragment that binds the Fc receptor of effector cells. Preferred antibodies for use in the subject teaching bind the Fc receptor of effector cells at a site which is not bound by endogenous immunoglobulin.

[0219] As used herein, the term "effector cell" refers to an immune cell which is involved in the effector phase of an immune response, as opposed to the cognitive and activation phases of an immune response. Exemplary immune cells include cells of myeloid or lymphoid origin, e.g, lymphocytes (e.g., B cells and T cells including cytolytic T cells (CTLs), killer cells, natural killer cells, macrophages, monocytes, eosinophils, neutrophils, polymorphonuclear cells, granulocytes, mast cells, and basophils. Some effector cells express specific Fc receptors and carry out specific immune functions. In preferred embodiments, an effector cell is capable of inducing antibody-dependent cellular cytotoxicity (ADCC), e.g., a neutrophil capable of inducing ADCC. For example, monocytes, macrophages, which express FcR are involved in specific killing of target cells and presenting antigens to other components of the immune system, or binding to cells that present antigens. In other embodiments, an effector cell can phagocytose a target antigen, target cell, or microorganism. The expression of a particular FcR on an effector cell can be regulated by humoral factors such as cytokines. For example, expression of Fc-gammaRI has been found to be up-regulated by interferon gamma (IFN-y). This enhanced

expression increases the cytotoxic activity of Fc-gammaRI-bearing cells against targets. An effector cell can phagocytose or lyse a target antigen or a target cell.

[0220] "Target cell" shall mean any undesirable cell in a subject (e.g., a human or animal) that can be targeted by an antibody of the teaching. In preferred embodiments, the target cell is a cell expressing or overexpressing CLD18. Cells expressing CLD18 typically include tumor cells.

[0221] Bispecific and multispecific molecules of the present teaching can be made using chemical techniques (see e.g., D. M. Kranz et al. (1981) Proc. Natl. Acad. Sci. USA 78:5807), "polydoma" techniques (See US 4,474,893, to Reading), or recombinant DNA techniques.

[0222] In particular, bispecific and multispecific molecules of the present teaching can be prepared by conjugating the constituent binding specificities, e.g., the anti-FcR and anti-CLD18 binding specificities, using methods known in the art. For example, each binding specificity of the bispecific and multispecific molecule can be generated separately and then conjugated to one another. When the binding specificities are proteins or peptides, a variety of coupling or cross-linking agents can be used for covalent conjugation. Examples of cross-linking agents include protein A, carbodiimide, N-succinimidyl-S-acetyl-thioacetate (SATA), 5,5'-dithiobis(2-nitrobenzoic acid) (DTNB), o-phenylenedimaleimide (oPDM), N-succinimidyl-3-(2-pyridyldithio)propionate (SPDP), and sulfosuccinimidyl-4-(N-maleimidomethyl)cyclohexane-1-carboxylate (sulfo-SMCC) (see e.g., Karpovsky et al. (1984) J. Exp. Med. 160: 1686; Liu, MA et al. (1985) Proc. Natl. Acad. Sci. USA 82: 8648). Other methods include those described by Paulus (Behring Ins. Mitt. (1985) No. 78,118-132); Brennan et al. (Science (1985) 229: 81-83), and Glennie et al. (J. Immunol. (1987) 139: 2367-2375). Preferred conjugating agents are SATA and sulfo-SMCC, both available from Pierce Chemical Co. (Rockford, IL).

[0223] When the binding specificities are antibodies, they can be conjugated via sulfhydryl bonding of the C-terminus hinge regions of the two heavy chains. In a particularly preferred embodiment, the hinge region is modified to contain an odd number of sulfhydryl residues, preferably one, prior to conjugation.

[0224] Alternatively, both binding specificities can be encoded in the same vector and expressed and assembled in the same host cell. This method is particularly useful where the bispecific and multispecific molecule is a mAb × mAb, mAb × Fab, Fab × $F(ab')_2$ or ligand × Fab fusion protein. A bispecific and multispecific molecule of the teaching, e.g., a bispecific molecule, can be a single chain molecule, such as a single chain bispecific antibody, a single chain bispecific molecule comprising one single chain antibody and a binding determinant, or a single chain bispecific molecule comprising two binding determinants. Bispecific and multispecific molecules can also be single chain molecules or may comprise at least two single chain molecules. Methods for preparing bi-and multispecific molecules are described for example in US 5,260,203; US 5,455,030; US 4,881,175; US 5,132,405; US 5,091,513; US 5,476,786; US 5,013,653; US 5,258,498; and US 5,482,858.

[0225] Binding of the bispecific and multispecific molecules to their specific targets can be confirmed by enzyme-linked immunosorbent assay (ELISA), a radioimmunoassay (RIA), FACS analysis, a bioassay (e.g., growth inhibition), or a Western Blot Assay. Each of these assays generally detects the presence of protein-antibody complexes of particular interest by employing a labeled reagent (e.g., an antibody) specific for the complex of interest. For example, the FcR-antibody complexes can be detected using e.g., an enzyme-linked antibody or antibody fragment which recognizes and specifically binds to the antibody-FcR complexes. Alternatively, the complexes can be detected using any of a variety of other immunoassays. For example, the antibody can be radioactively labeled and used in a radioimmunoassay (RIA) (see, for example, Weintraub, B., Principles of Radioimmunoassays, Seventh Training Course on Radioligand Assay Techniques, The Endocrine Society, March, 1986). The radioactive isotope can be detected by such means as the use of a γ-counter or a scintillation counter or by autoradiography.

II. Immunoconjugates

[0226] In another aspect, the present teaching features an anti-CLD18 antibody conjugated to a therapeutic moiety or agent, such as a cytotoxin, a drug (e.g., an immunosuppressant) or a radioisotope. Such conjugates are referred to herein as "immunoconjugates". Immunoconjugates which include one or more cytotoxins are referred to as "immunotoxins". A cytotoxin or cytotoxic agent includes any agent that is detrimental to and, in particular, kills cells. Examples include taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or homologs thereof.

[0227] Suitable therapeutic agents for forming immunoconjugates of the teaching include, but are not limited to, antimetabolites (e.g., methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, fludarabin, 5-fluorouracil decarbazine), alkylating agents (e.g., mechlorethamine, thioepa chlorambucil, melphalan, carmustine (BSNU) and lomustine (CCNU), cyclophosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin), anthracyclines (e.g., daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (e.g., dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC), and anti-mitotic agents (e.g., vincristine and vinblastine). In a preferred embodiment, the therapeutic agent is a cytotoxic agent or a radiotoxic agent. In another embodiment, the therapeutic agent is an immunosuppressant. In yet another embodiment, the therapeutic agent is GM-CSF. In a preferred embodiment, the therapeutic agent is doxorubicin, cisplatin, bleomycin, sulfate, carmustine, chlorambucil, cyclophosphamide or ricin A.

[0228] Antibodies of the present teaching also can be conjugated to a radioisotope, e.g., iodine-131, yttrium-90 or indium-111, to generate cytotoxic radiopharmaceuticals for treating a CLD18-related disorder, such as a cancer. The antibody conjugates of the teaching can be used to modify a given biological response, and the drug moiety is not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety may be a protein or polypeptide possessing a desired biological activity. Such proteins may include, for example, an enzymatically active toxin, or active fragment thereof, such as abrin, ricin A, pseudomonas exotoxin, or diphtheria toxin; a protein such as tumor necrosis factor or interferon-y; or, biological response modifiers such as, for example, lymphokines, interleukin-1 ("IL-1"), interleukin-2 ("IL-2"), interleukin-6 ("IL-6"), granulocyte macrophage colony stimulating factor ("GM-CSF"), granulocyte colony stimulating factor ("G-CSF"), or other growth factors.

[0229] Techniques for conjugating such therapeutic moiety to antibodies are well known, see, e.g., Arnon et al., "Monoclonal Antibodies For Immunotargeting Of Drugs In Cancer Therapy", in Monoclonal Antibodies And Cancer Therapy, Reisfeld et al. (eds.), pp. 243-56 (Alan R. Liss, Inc. 1985); Hellstrom et al., "Antibodies For Drug Delivery", in Controlled Drug Delivery (2nd Ed.), Robinson et al. (eds.), pp. 623-53 (Marcel Dekker, Inc. 1987); Thorpe, "Antibody Carriers Of Cytotoxic Agents In Cancer Therapy: A Review", in Monoclonal Antibodies '84: Biological And Clinical Applications, Pincheraet al. (eds.), pp. 475-506 (1985); "Analysis, Results, And Future Prospective Of The Therapeutic Use Of Radiolabeled Antibody In Cancer Therapy", in Monoclonal Antibodies For Cancer Detection And Therapy, Baldwin et al. (eds.), pp. 303-16 (Academic Press 1985), and Thorpe et al., "The Preparation And Cytotoxic Properties Of Antibody-Toxin Conjugates", Immunol. Rev., 62: 119-58 (1982).

[0230] In a further embodiment, the antibodies according to the teaching are attached to a linker-chelator, e.g., tiuxetan, which allows for the antibody to be conjugated to a radioisotope.

III. Pharmaceutical Compositions

[0231] In another aspect, the present teaching provides a composition, e.g., a pharmaceutical composition, containing one or a combination of antibodies of the present teaching. The pharmaceutical compositions may be formulated with pharmaceutically acceptable carriers or diluents as well as any other known adjuvants and excipients in accordance with conventional techniques such as those disclosed in Remington: The Science and Practice of Pharmacy, 19th Edition, Gennaro, Ed., Mack Publishing Co., Easton, PA, 1995. In one embodiment, the

compositions include a combination of multiple (e.g., two or more) isolated antibodies of the teaching which act by different mechanisms, e.g., one antibody which predominately acts by inducing CDC in combination with another antibody which predominately acts by inducing apoptosis.

[0232] Pharmaceutical compositions of the teaching also can be administered in combination therapy, i.e., combined with other agents. For example, the combination therapy can include a composition of the present teaching with at least one anti-inflammatory agent or at least one immunosuppressive agent. In one embodiment such therapeutic agents include one or more anti-inflammatory agents, such as a steroidal drug or a NSAID (nonsteroidal anti-inflammatory drug). Preferred agents include, for example, aspirin and other salicylates, Cox-2 inhibitors, such as rofecoxib (Vioxx) and celecoxib (Celebrex), NSAIDs such as ibuprofen (Motrin, Advil), fenoprofen (Nalfon), naproxen (Naprosyn), sulindac (Clinoril), diclofenac (Voltaren), piroxicam (Feldene), ketoprofen (Orudis), diflunisal (Dolobid), nabumetone (Relafen), etodolac (Lodine), oxaprozin (Daypro), and indomethacin (Indocin).

[0233] In another embodiment, such therapeutic agents include agents leading to the depletion or functional inactivation of regulatory T cells like low dose cyclophosphamid, anti-CTLA4 antibodies, anti-IL2 or anti-IL2-receptor antibodies.

[0234] In yet another embodiment, such therapeutic agents include one or more chemotherapeutics, such as Taxol derivatives, taxotere, gemcitabin, 5-Fluoruracil, doxorubicin (Adriamycin), cisplatin (Platinol), cyclophosphamide (Cytoxan, Procytox, Neosar). In another embodiment, antibodies of the present teaching may be administered in combination with chemotherapeutic agents, which preferably show therapeutic efficacy in patients suffering from stomach, esophageal, pancreatic and lung cancer.

[0235] In yet another embodiment, the antibodies of the teaching may be administered in conjunction with radiotherapy and/or autologous peripheral stem cell or bone marrow transplantation.

[0236] In still another embodiment, the antibodies of the teaching may be administered in combination with one or more antibodies selected from anti-CD25 antibodies, anti-EPCAM antibodies, anti-EGFR, anti-Her2/neu, and anti-CD40 antibodies.

[0237] In yet a further embodiment, the antibodies of the teaching may be administered in combination with an anti-C3b(i) antibody in order to enhance complement activation.

[0238] As used herein, "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents, and the like that are physiologically compatible. Preferably, the carrier is suitable for intravenous, intramuscular, subcutaneous, parenteral, spinal or epidermal administration (e.g., by injection or infusion). Depending on the route of administration, the active compound, i.e., antibody, bispecific and multispecific molecule, may be coated in a material to protect the compound from the action of acids and other natural conditions that may inactivate the compound.

[0239] A "pharmaceutically acceptable salt" refers to a salt that retains the desired biological activity of the parent compound and does not impart any undesired toxicological effects (see e.g., Berge, S. M., et al. (1977) J. Pharm. Sci. 66: 1-19).

[0240] Examples of such salts include acid addition salts and base addition salts. Acid addition salts include those derived from nontoxic inorganic acids, such as hydrochloric, nitric, phosphoric, sulfuric, hydrobromic, hydroiodic, phosphorous and the like, as well as from nontoxic organic acids such as aliphatic mono- and dicarboxylic acids, phenyl-substituted alkanoic acids, hydroxy alkanoic acids, aromatic acids, aliphatic and aromatic sulfonic acids and the like. Base addition salts include those derived from alkaline earth metals, such as sodium, potassium, magnesium, calcium and the like, as well as from nontoxic organic amines, such as N,N'-dibenzylethylenediamine, N-methylglucamine, chloroprocaine, choline, diethanolamine, ethylenediamine, procaine and the like.

[0241] A composition of the present teaching can be administered by a variety of methods known in the art. As will be appreciated by the skilled artisan, the route and/or mode of administration will vary depending upon the desired results. The active compounds can be prepared with carriers that will protect the compound against rapid release, such as a controlled release formulation, including implants, transdermal patches, and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for the preparation of such formulations are generally known to those skilled in the art. See, e.g., Sustained and Controlled Release Drug Delivery Systems, J. R. Robinson, ed., Marcel Dekker, Inc., New York, 1978.

[0242] To administer a compound of the teaching by certain routes of administration, it may be necessary to coat the compound with, or co-administer the compound with, a material to prevent its inactivation. For example, the compound may be administered to a subject in an appropriate carrier, for example, liposomes, or a diluent. Pharmaceutically acceptable diluents include saline and aqueous buffer solutions. Liposomes include water-in-oil-in-water CGF emulsions as well as conventional liposomes (Strejan et al. (1984) J. Neuroimmunol. 7: 27).

[0243] Pharmaceutically acceptable carriers include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersions. The use of such media and agents for pharmaceutically active substances is known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the pharmaceutical compositions of the teaching is contemplated. Supplementary active compounds can also be incorporated into the compositions.

[0244] Therapeutic compositions typically must be sterile and stable under the conditions of manufacture and storage. The composition can be formulated as a solution, microemulsion, liposome, or other ordered structure suitable to high drug concentration. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as mannitol, sorbitol, or sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent that delays absorption, for example, monostearate salts and gelatin.

[0245] Sterile injectable solutions can be prepared by incorporating the active compound in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by sterilization microfiltration.

[0246] Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and freeze-drying (lyophilization) that yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

[0247] Dosage regimens are adjusted to provide the optimum desired response (e.g., a therapeutic response). For example, a single bolus may be administered, several divided doses may be administered over time or the dose may be proportionally reduced or increased as indicated by the exigencies of the therapeutic situation. It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the subjects to be treated; each unit contains a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the teaching are dictated by and directly dependent on (a) the unique characteristics of the active compound and the particular therapeutic effect to be achieved, and (b) the limitations inherent in the art of compounding such an active compound for the treatment of sensitivity in individuals.

[0248] Examples of pharmaceutically-acceptable antioxidants include: (1) water soluble antioxidants, such as ascorbic acid, cysteine hydrochloride, sodium bisulfate, sodium metabisulfite, sodium sulfite and the like; (2) oil-soluble antioxidants, such as ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), lecithin, propyl gallate, alpha-tocopherol, and the like; and (3) metal chelating agents, such as citric acid, ethylenediamine tetraacetic acid (EDTA), sorbitol, tartaric acid, phosphoric acid, and the like.

[0249] For the therapeutic compositions, formulations of the present teaching include those suitable for oral, nasal, topical (including buccal and sublingual), rectal, vaginal and/or parenteral administration. The formulations may conveniently be presented in unit dosage form and may be prepared by any methods known in the art of pharmacy. The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will vary depending upon the subject being treated, and the particular mode of administration. The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will generally be that amount of the composition which produces a therapeutic effect.

[0250] Generally, out of one hundred per cent, this amount will range from about 0.01 per cent to about ninety-nine percent of active ingredient, preferably from about 0.1 percent to about 70 percent, most preferably from about 1 percent to about 30 percent.

[0251] Formulations of the present teaching which are suitable for vaginal administration also include pessaries, tampons, creams, gels, pastes, foams or spray formulations containing such carriers as are known in the art to be appropriate. Dosage forms for the topical or transdermal administration of compositions of this teaching include powders, sprays, ointments, pastes, creams, lotions, gels, solutions, patches and inhalants. The active compound may be mixed under sterile conditions with a pharmaceutically acceptable carrier, and with any preservatives, buffers, or propellants which may be required.

[0252] The phrases "parenteral administration" and "administered parenterally" as used herein means modes of administration other than enteral and topical administration, usually by injection, and includes, without limitation, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intraorbital, intracardiac, intradermal, intraperitoneal, transtracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal, epidural and intrasternal injection and infusion.

[0253] Examples of suitable aqueous and nonaqueous carriers which may be employed in the pharmaceutical compositions of the teaching include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures thereof, vegetable oils, such as olive oil, and injectable organic esters, such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of coating materials, such as lecithin, by the maintenance of the required particle size in the case of dispersions, and by the use of surfactants.

[0254] These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of the presence of microorganisms may be ensured both by sterilization procedures, and by the inclusion of various antibacterial and antifungal agents, for example, paraben, chlorobutanol, phenol sorbic acid, and the like. It may also be desirable to include isotonic agents, such as sugars, sodium chloride, and the like into the compositions. In addition, prolonged absorption of the injectable pharmaceutical form may be brought about by the inclusion of agents which delay absorption such as aluminum monostearate and gelatin.

[0255] In one embodiment the monoclonal antibodies of the teaching are administered in crystalline form by subcutaneous injection, cf. Yang et al. (2003) PNAS, 100 (12): 6934-6939. When the compounds of the present teaching are administered as pharmaceuticals, to humans and animals, they can be given alone or as a pharmaceutical composition containing, for example, 0.01 to 99.5% (more preferably, 0.1 to 90%) of active ingredient in combination with a pharmaceutically acceptable carrier.

[0256] Regardless of the route of administration selected, the compounds of the present teaching, which may be used in a suitable hydrated form, and/or the pharmaceutical compositions of the present teaching, are formulated

into pharmaceutically acceptable dosage forms by conventional methods known to those of skill in the art.

[0257] Actual dosage levels of the active ingredients in the pharmaceutical compositions of the present teaching may be varied so as to obtain an amount of the active ingredient which is effective to achieve the desired therapeutic response for a particular patient, composition, and mode of administration, without being toxic to the patient. The selected dosage level will depend upon a variety of pharmacokinetic factors including the activity of the particular compositions of the present teaching employed, the route of administration, the time of administration, the rate of excretion of the particular compound being employed, the duration of the treatment, other drugs, compounds and/or materials used in combination with the particular compositions employed, the age, sex, weight, condition, general health and prior medical history of the patient being treated, and like factors well known in the medical arts.

[0258] A physician or veterinarian having ordinary skill in the art can readily determine and prescribe the effective amount of the pharmaceutical composition required. For example, the physician or veterinarian could start doses of the compounds of the teaching employed in the pharmaceutical composition at levels lower than that required in order to achieve the desired therapeutic effect and gradually increase the dosage until the desired effect is achieved. In general, a suitable daily dose of a composition of the teaching will be that amount of the compound which is the lowest dose effective to produce a therapeutic effect. Such an effective dose will generally depend upon the factors described above. It is preferred that administration be intravenous, intramuscular, intraperitoneal, or subcutaneous, preferably administered proximal to the site of the target. If desired, the effective daily dose of a therapeutic composition may be administered as two, three, four, five, six or more sub-doses administered separately at appropriate intervals throughout the day, optionally, in unit dosage forms. While it is possible for a compound of the present teaching to be administered alone, it is preferable to administer the compound as a pharmaceutical formulation (composition).

[0259] In one embodiment, the antibodies of the teaching may be administered by infusion, preferably slow continuous infusion over a long period, such as more than 24 hours, in order to reduce toxic side effects. The administration may also be performed by continuous infusion over a period of from 2 to 24 hours, such as of from 2 to 12 hours. Such regimen may be repeated one or more times as necessary, for example, after 6 months or 12 months. The dosage can be determined or adjusted by measuring the amount of circulating monoclonal anti-CLD18 antibodies upon administration in a biological sample by using anti-idiotypic antibodies which target the anti-CLD18 antibodies.

[0260] In yet another embodiment, the antibodies are administered by maintenance therapy, such as, e.g., once a week for a period of 6 months or more.

[0261] In still another embodiment, the antibodies according to the teaching may be administered by a regimen including one infusion of an antibody against CLD18 followed by an infusion of an antibody against CLD18 conjugated to a radioisotope. The regimen may be repeated, e.g., 7 to 9 days later.

[0262] Therapeutic compositions can be administered with medical devices known in the art. For example, in a preferred embodiment, a therapeutic composition of the teaching can be administered with a needleless hypodermic injection device, such as the devices disclosed in US 5,399,163; US 5,383,851; US 5,312,335; US 5,064,413; US 4,941,880; US 4,790,824; or US 4,596,556. Examples of well-known implants and modules useful in the present teaching include those described in: US 4,487,603, which discloses an implantable micro-infusion pump for dispensing medication at a controlled rate; US 4,486,194, which discloses a therapeutic device for administering medicants through the skin; US 4,447,233, which discloses a medication infusion pump for delivering medication at a precise infusion rate; US 4,447,224, which discloses a variable flow implantable infusion apparatus for continuous drug delivery; US 4,439,196, which discloses an osmotic drug delivery system having multi-chamber compartments; and US 4,475,196, which discloses an osmotic drug delivery system.

[0263] Many other such implants, delivery systems, and modules are known to those skilled in the art. In certain embodiments, the antibodies of the teaching can be formulated to ensure proper distribution in vivo. For example,

the blood-brain barrier (BBB) excludes many highly hydrophilic compounds. To ensure that the therapeutic compounds of the teaching cross the BBB (if desired), they can be formulated, for example, in liposomes. For methods of manufacturing liposomes, see, e.g., US 4,522,811; US 5,374,548; and US 5,399,331. The liposomes may comprise one or more moieties which are selectively transported into specific cells or organs, and thus enhance targeted drug delivery (see, e.g., V.V. Ranade (1989) J. Clin. Pharmacol. 29: 685). Exemplary targeting moieties include folate or biotin (see, e.g., US 5,416,016 to Low et al.); mannosides (Umezawa et al., (1988) Biochem. Biophys. Res. Commun. 153: 1038); antibodies (P.G. Bloeman et al. (1995) FEBS Lett. 357: 140; M. Owais et al. (1995) Antimicrob. Agents Chemother. 39: 180); and surfactant protein A receptor (Briscoe et al. (1995) Am. J. Physiol. 1233: 134).

[0264] In one embodiment of the teaching, the therapeutic compounds of the teaching are formulated in liposomes. In a more preferred embodiment, the liposomes include a targeting moiety. In a most preferred embodiment, the therapeutic compounds in the liposomes are delivered by bolus injection to a site proximal to the desired area, e.g., the site of a tumor. The composition must be fluid to the extent that easy syringability exists. It must be stable under the conditions of manufacture and storage and must be preserved against the contaminating action of microorganisms such as bacteria and fungi.

[0265] In a further embodiment, antibodies of the teaching can be formulated to prevent or reduce their transport across the placenta. This can be done by methods known in the art, e.g., by PEGylation of the antibodies or by use of F(ab)2' fragments. Further references can be made to "Cunningham-Rundles C, Zhuo Z, Griffith B, Keenan J. (1992) Biological activities of polyethylene-glycol immunoglobulin conjugates. Resistance to enzymatic degradation. J. Immunol. Methods, 152: 177-190; and to "Landor M. (1995) Maternal-fetal transfer of immunoglobulins, Ann. Allergy Asthma Immunol. 74: 279-283.

[0266] A "therapeutically effective dosage" for tumor therapy can be measured by objective tumor responses which can either be complete or partial. A complete response (CR) is defined as no clinical, radiological or other evidence of disease. A partial response (PR) results from a reduction in aggregate tumor size of greater than 50%. Median time to progression is a measure that characterizes the durability of the objective tumor response.

[0267] A "therapeutically effective dosage" for tumor therapy can also be measured by its ability to stabilize the progression of disease. The ability of a compound to inhibit cancer can be evaluated in an animal model system predictive of efficacy in human tumors. Alternatively, this property of a composition can be evaluated by examining the ability of the compound to inhibit cell growth or apoptosis by in vitro assays known to the skilled practitioner. A therapeutically effective amount of a therapeutic compound can decrease tumor size, or otherwise ameliorate symptoms in a subject. One of ordinary skill in the art would be able to determine such amounts based on such factors as the subject's size, the severity of the subject's symptoms, and the particular composition or route of administration selected.

[0268] The composition must be sterile and fluid to the extent that the composition is deliverable by syringe. In addition to water, the carrier can be an isotonic buffered saline solution, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyetheylene glycol, and the like), and suitable mixtures thereof. Proper fluidity can be maintained, for example, by use of coating such as lecithin, by maintenance of required particle size in the case of dispersion and by use of surfactants. In many cases, it is preferable to include isotonic agents, for example, sugars, polyalcohols such as mannitol or sorbitol, and sodium chloride in the composition. Long-term absorption of the injectable compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate or gelatin.

[0269] When the active compound is suitably protected, as described above, the compound may be orally administered, for example, with an inert diluent or an assimilable edible carrier.

IV. Uses and Methods of the Teaching

[0270] The antibodies (including immunoconjugates, bispecifics/multispecifics, compositions and other derivatives described herein) of the present teaching have numerous therapeutic utilities involving the treatment of disorders involving cells expressing CLD18. For example, the antibodies can be administered to cells in culture, e.g., in vitro or ex vivo, or to human subjects, e.g., in vivo, to treat or prevent a variety of disorders such as those described herein. As used herein, the term "subject" is intended to include human and non-human animals which respond to the antibodies against CLD18. Preferred subjects include human patients having disorders that can be corrected or ameliorated by killing diseased cells, in particular cells characterized by an altered expression pattern of CLD18 compared to normal cells.

[0271] A therapeutic effect in the treatments discussed herein is preferably achieved through the functional properties of the antibodies of the teaching to mediate killing of cells e.g. by inducing complement dependent cytotoxicity (CDC) mediated lysis, antibody dependent cellular cytotoxicity (ADCC) mediated lysis, apoptosis, homotypic adhesion, and/or phagocytosis, preferably by inducing CDC mediated lysis and/or ADCC mediated lysis.

[0272] For example, in one embodiment, antibodies of the present teaching can be used to treat a subject with a tumorigenic disorder, e.g., a disorder characterized by the presence of tumor cells expressing CLD18 including, for example, gastric cancer. Examples of tumorigenic diseases which can be treated and/or prevented encompass all CLD18 expressing cancers and tumor entities including stomach cancer, esophageal cancer, pancreatic cancer, lung cancer, ovarian cancer, breast cancer, colorectal cancer, hepatic cancer, cancer of the gallbladder and head-neck cancer. These cancers may be in early, intermediate or advanced stages, e.g. metastasis.

[0273] The pharmaceutical compositions and methods of treatment described according to the teaching may also be used for immunization or vaccination to prevent a disease described herein.

[0274] In another embodiment, antibodies of the teaching can be used to detect levels of CLD18 or particular forms of CLD18, or levels of cells which contain CLD18 on their membrane surface, which levels can then be linked to certain diseases or disease symptoms such as described above. Alternatively, the antibodies can be used to deplete or interact with the function of CLD18 expressing cells, thereby implicating these cells as important mediators of the disease. This can be achieved by contacting a sample and a control sample with the anti-CLD18 antibody under conditions that allow for the formation of a complex between the antibody and CLD18. Any complexes formed between the antibody and CLD18 are detected and compared in the sample and a control sample, i.e. a reference sample.

[0275] Antibodies of the teaching can be initially tested for their binding activity associated with therapeutic or diagnostic uses in vitro. For example, the antibodies can be tested using flow cytometric assays as described herein.

[0276] Moreover, activity of the antibodies in triggering at least one effector-mediated effector cell activity, including inhibiting the growth of and/or killing of cells expressing CLD18, can be assayed. For example, the ability of the antibodies to trigger CDC and/or apoptosis can be assayed. Protocols for assaying for CDC, homotypic adhesion, molecular clustering or apoptosis are described herein.

[0277] The antibodies of the teaching can be used to elicit in vivo or in vitro one or more of the following biological activities: to inhibit the growth of and/or differentiation of a cell expressing CLD18; to kill a cell expressing CLD18; to mediate phagocytosis or ADCC of a cell expressing CLD18 in the presence of effector cells; to mediate CDC of a cell expressing CLD18 in the presence of complement; to mediate apoptosis of a cell expressing CLD18; to induce homotypic adhesion; and/or to induce translocation into lipid rafts upon binding CLD18.

[0278] In a particular embodiment, the antibodies are used in vivo or in vitro to treat, prevent or diagnose a variety of CLD18-related diseases. Examples of CLD18-related diseases include, among others, cancers such as gastric cancer, pancreatic cancer, esophageal cancer, lung cancer and cancers as those listed above.

[0279] CLD18A2 is also expressed in differentiated normal stomach cells. Possible antibody induced clinical side effects by killing of these cells may be reduced or avoided by parallel administration of stomach protective drugs such as antacida, or inhibitors of the gastric proton pump such as omeprazol or related drugs.

[0280] Suitable routes of administering the antibody compositions of the teaching in vivo and in vitro are well known in the art and can be selected by those of ordinary skill.

[0281] As described above, anti-CLD18 antibodies of the teaching can be co-administered with one or other more therapeutic agents, e.g., a cytotoxic agent, a radiotoxic agent, antiangiogeneic agent or and immunosuppressive agent to reduce the induction of immune responses against the antibodies of teaching. The antibody can be linked to the agent (as an immunocomplex) or can be administered separate from the agent. In the latter case (separate administration), the antibody can be administered before, after or concurrently with the agent or can be co-administered with other known therapies, e.g., an anti-cancer therapy, e.g., radiation. Such therapeutic agents include, among others, anti-neoplastic agents such as listed above. Co-administration of the anti-CLD18 antibodies of the present teaching with chemotherapeutic agents provides two anti-cancer agents which operate via different mechanisms yielding a cytotoxic effect to tumor cells. Such co-administration can solve problems due to development of resistance to drugs or a change in the antigenicity of the tumor cells which would render them unreactive with the antibody.

[0282] In another particular embodiment of the teaching, the subject being administered the antibody is additionally treated with an antiagionic agent including antibodies targeting VEGF or VEGFR and one or more chemical compounds inhibiting angiogenesis. Pretreatment with or parallel applicatition of these drugs may improve the penetration of antibodies in bulk tumors.

[0283] In another particular embodiment of the teaching, the subject being administered the antibody is additionally treated with a compound inhibiting growth factor receptor signaling including monoclonal antibodies binding to the EGFR receptor as well as chemical compounds inhibiting signaling initiated by the EGFR, Her1 or Her2/neu receptor.

[0284] Target-specific effector cells, e.g., effector cells linked to compositions (e.g. antibodies, multispecific and bispecific molecules) of the teaching can also be used as therapeutic agents. Effector cells for targeting can be human leukocytes such as macrophages, neutrophils or monocytes. Other cells include eosinophils, natural killer cells and other IgG-or IgA-receptor bearing cells. If desired, effector cells can be obtained from the subject to be treated. The target-specific effector cells can be administered as a suspension of cells in a physiologically acceptable solution. The number of cells administered can be in the order of 10^8 to 10^9 but will vary depending on the therapeutic purpose. In general, the amount will be sufficient to obtain localization at the target cell, e.g., a tumor cell expressing CLD18, and to effect cell killing by, e.g., phagocytosis. Routes of administration can also vary.

[0285] Therapy with target-specific effector cells can be performed in conjunction with other techniques for removal of targeted cells. For example, anti-tumor therapy using the compositions of the teaching and/or effector cells armed with these compositions can be used in conjunction with chemotherapy. Additionally, combination immunotherapy may be used to direct two distinct cytotoxic effector populations toward tumor cell rejection. For example, anti-CLD18 antibodies linked to anti-Fc-RI or anti-CD3 may be used in conjunction with IgG- or IgA-receptor specific binding agents.

[0286] Bispecific and multispecific molecules of the teaching can also be used to modulate Fc-gammaR or Fc-alphaR levels on effector cells, such as by capping and eliminating receptors on the cell surface. Mixtures of anti-Fc receptors can also be used for this purpose.

[0287] The compositions (e.g., antibodies, multispecific and bispecific molecules and immunoconjugates) of the teaching which have complement binding sites, such as portions from IgG1, -2, or -3 or IgM which bind complement, can also be used in the presence of complement. In one embodiment, ex vivo treatment of a

population of cells comprising target cells with a binding agent of the teaching and appropriate effector cells can be supplemented by the addition of complement or serum containing complement. Phagocytosis of target cells coated with a binding agent of the teaching can be improved by binding of complement proteins. In another embodiment target cells coated with the compositions of the teaching can also be lysed by complement. In yet another embodiment, the compositions of the teaching do not activate complement.

[0288] The compositions of the teaching can also be administered together with complement. Accordingly, within the scope of the teaching are compositions comprising antibodies, multispecific or bispecific molecules and serum or complement. These compositions are advantageous in that the complement is located in close proximity to the antibodies, multispecific or bispecific molecules.

[0289] Alternatively, the antibodies, multispecific or bispecific molecules of the teaching and the complement or serum can be administered separately. Binding of the compositions of the present teaching to target cells may cause translocation of the CLD18 antigen-antibody complex into lipid rafts of the cell membrane. Such translocation creates a high density of antigen-antibody complexes which may efficiently activate and/or enhance CDC.

[0290] Also within the scope of the present teaching are kits comprising the antibody compositions of the teaching (e.g., antibodies and immunoconjugates) and instructions for use. The kit can further contain one or more additional reagents, such as an immunosuppressive reagent, a cytotoxic agent or a radiotoxic agent, or one or more additional antibodies of the teaching (e.g., an antibody having a complementary activity).

[0291] Accordingly, patients treated with antibody compositions of the teaching can be additionally administered (prior to, simultaneously with, or following administration of a antibody of the teaching) with another therapeutic agent, such as a cytotoxic or radiotoxic agent, which enhances or augments the therapeutic effect of the antibodies of the teaching.

[0292] In other embodiments, the subject can be additionally treated with an agent that modulates, e.g., enhances or inhibits, the expression or activity of Fc-gamma or Fc-alpha receptors by, for example, treating the subject with a cytokine. Preferred cytokines include granulocyte colony-stimulating factor (G-CSF), granulocyte-macrophage colony-stimulating factor (GM-CSF), interferon-y (IFN-y), and tumor necrosis factor (TNF). Other important agents for increasing the therapeutic efficacy of the antibodies and pharmaceutical compositions described herein are β-glucans which are homopolysaccharides of branched glucose residues and are produced by a variety of plants and microorganisms, for example, bacteria, algae, fungi, yeast and grains. Fragments of β-glucans produced by organisms may be also be used. Preferably, the β-glucan is a polymer of β(1,3) glucose wherein at least some of the backbone glucose units, e.g. 3-6 % of the backbone glucose units, possess branches such as β(1,6) branches.

[0293] In a particular embodiment, the teaching provides methods for detecting the presence of CLD18 antigen in a sample, or measuring the amount of CLD18 antigen, comprising contacting the sample, and a control sample, with a antibody which specifically binds to CLD18, under conditions that allow for formation of a complex between the antibody or portion thereof and CLD18. The formation of a complex is then detected, wherein a difference complex formation between the sample compared to the control sample is indicative for the presence of CLD18 antigen in the sample.

[0294] In still another embodiment, the teaching provides a method for detecting the presence or quantifying the amount of CLD18-expressing cells in vivo or in vitro. The method comprises (i) administering to a subject a composition of the teaching conjugated to a detectable marker; (ii) exposing the subject to a means for detecting said detectable marker to identify areas containing CLD18-expressing cells.

[0295] Methods as described above are useful, in particular, for diagnosing CLD18-related diseases and/or the localization of CLD18-related diseases such as cancer diseases. Preferably an amount of CLD18, preferably CLD18-A2 in a sample which is higher than the amount of CLD18, preferably CLD18-A2, in a control sample is

indicative for the presence of a CLD18-related disease in a subject, in particular a human, from which the sample is derived.

[0296] In yet another embodiment immunoconjugates of the teaching can be used to target compounds (e.g., therapeutic agents, labels, cytotoxins, radiotoxins immunosuppressants, etc.) to cells which have CLD18 expressed on their surface by linking such compounds to the antibody. Thus, the teaching also provides methods for localizing ex vivo or in vitro cells expressing CLD18, such as circulating tumor cells.

[0297] The present teaching is further illustrated by the following examples which are not be construed as limiting the scope of the teaching.

EXAMPLES

1. Generation of murine antibodies against CLD18

a. Immunizations:

[0298] Balb/c or C57/BL6 mice were immunized with eucaryotic expression vectors, encoding human CLD18 fragments (SEQ ID NO: 15, 16; 17, 18). 50 µg or 25 µg of plasmid DNA was injected into the quadriceps (intramuscular, i.m.) on days 1 and 10 for generation of monoclonal antibodies of Set1 or alternatively on days 1 and 9, 1 and 11, or 1, 16 and 36 for generation of monoclonal antibodies of Set2 in the presence of adjuvants, for example CpG (for details see Tab. 1b). CpG as well as cells transfected with CLD18A2 (SEQ ID NO: 1) alone or co-transfected additionally with murine soluble CD40L encoding RNA were injected intramuscularly, PEI-Man was injected intramuscularly or intraperitonally. The presence of antibodies directed against human CLD18 in sera of mice was monitored by immune fluorescence microscopy between day 16 and 43 depending on the specific immunization protocol used. The immune fluorescence was determined using HEK293 cells transiently transfected with a nucleic acid encoding a fusion construct comprising human CLD18A2 (SEQ ID NOs: 1, 2) and a fluorescent reporter protein. Mice with detectable immune responses (Fig. 1) were boosted three days prior to splenectomy for generation of monoclonal antibodies of Set1, or mice were boosted three days, three and two days, or mice were boosted four, three and two days prior to splenectomy for generation of monoclonal antibodies of Set2 by intraperitonal injection of 5×10^7 or alternatively 1×10^8 HEK293 cells transiently transfected with a nucleic acid encoding human CLD18A2 (SEQ ID NOs: 1, 2) (for details see Tab. 1b). In Tab. 1a the immunization protocols used are dedicated to the respective monoclonal antibodies.

Tab. 1a: Immunisation protocols used for generation of monoclonal antibodies

mAB	Immunisation protocol*	mAB	Immunisation protocol
Set1			
24H5	40	42E12	45
26B5	40	43A11	45
26D 12	40	44E10	45
28D10	40	47D12	45
37G11	45	61C2	45
37H8	45	75B8	6
38G5	45	85A3	6
38H3	45	9E8	40
39F11	45	19B9	40
41C6	45		

Set2			
45C1	53	166E2	51
125E1	45	175D10	51
163E12	51		
* For specific immunization protocols see Tab. 1b			

Tab. 1b: Detailed immunisation protocols

Immunisation protocol	Immunisation (prime and boosts with DNA)			Serum - monitoring	Boosts with transfected cells		
	with DNA vectors encoding CLD18 fragments	with adjuvant	on day	on day	Cells transfected with CLD18A2 (SEQ ID NO: 1) alone	Cells co-transfected with CLD18A2 (SEQ ID NO: 1) and with murine soluble CD40L encoding RNA	days prior to splenectomy
6	SEQ ID NO: 15: 50µg	50µg CpG	1 and 10	18	5×10^7 transfected MC3T3 cells	none	3
40	SEQ ID NO: 17: 50µg	50µg CpG	1 and 10	18		5×10^7 HEK293 cells; 100µg CPG as adjuvant	3
45	SEQ ID NO: 15: 50µg	50µg CpG	1 and 9	16		1×10^8 HEK293 cells	3
51	SEQ ID NO: 15: 25µg	2,5 µl PEI-Man* (150 mM) in H_2O with 5% Glucose	1, 16 and 36	22, 30 and 43	5×10^7 transfected HEK293 cells	none	3 and 2
53	Priming: SEQ ID NO: 15: 25µg, and SEQ ID NO: 17 : 25µg; Boosting: SEQ ID NO: 17: 50µg	50µg CpG in in H_2O with 5% Glucose	1 and 11	20	5×10^7 transfected HEK293 cells	none	4, 3 and 2
* in vivo-jetPEI™-Man from PolyPlus Transfection							

b. Generation of hybridomas producing human monoclonal antibodies to CLD18:

[0299] Mouse splenocytes were isolated and fused with PEG to a mouse myeloma cell line based on standard

protocols. The resulting hybridomas were then screened for production of immunoglobulines with CLD18 specificity using HEK293 cells transfected with a nucleic acid encoding human CLD18 by FACS analysis.

[0300] Single cell suspensions of splenic lymphocytes from immunized mice were fused with P3X63Ag8U.1 nonsecreting mouse myeloma cells (ATCC, CRL 1597) in a 2:1 ratio using 50% PEG (Roche Diagnostics, CRL 738641). Cells were plated at approximately 3 × 10^4/well in flat bottom microtiter plates, followed by about two week incubation in selective medium containing 10% fetal bovine serum, 2% hybridoma fusion and cloning supplement (HFCS, Roche Diagnostics, CRL 1 363 735) plus 10 mM HEPES, 0.055 mM 2-mercaptoethanol, 50 µg/ml gentamycin and 1× HAT (Sigma, CRL H0262). After 10 to 14 days individual wells were screened by flow cytometry for anti-CLD18 monoclonal antibodies. The antibody secreting hybridomas were replated, screened again and, if still positive for anti-CLD18 monoclonal antibodies, were subcloned by limiting dilution. The stable subclones were then cultured in vitro to generate small amounts of antibody in tissue culture medium for characterization. At least one clone from each hybridoma, which retained the reactivity of parent cells (by FACS), was chosen. 9 vial cell banks were generated for each clone and stored in liquid nitrogen.

c. Selection of monoclonal antibodies binding to CLD18:

[0301] To determine the isotype of antibodies, an isotype ELISA was performed. The mouse monoAB ID Kit (Zymed, CRL 90-6550) or alternatively the IsoStrip Mouse Monoclonal Antibody Isotyping Kit (Roche, Cat. No. 1493027) was used to determine Ig subclasses of the identified CLD18 reactive monoclonal antibodies.

[0302] Defined as Set1, nineteen hybridoma cell lines were generated, six from a fusion of cells from a C57/BL6 mouse immunized with CLD18A2-LoopD3 (SEQ ID NOs: 17, 18), thirteen from a fusion of cells from a Balb/c mouse immunized with CLD18A2-Loop1 (SEQ ID NOs: 15, 16), expressing the following antibodies:

24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9

24H5: mouse monoclonal IgG2b, κ antibody, 182-D758-034

26B5: mouse monoclonal IgG2a, κ antibody, 182-D758-035, DSM ACC2745

26D12: mouse monoclonal IgG3, κ antibody, 182-D758-036, DSM ACC2746

28D10: mouse monoclonal IgG3, κ antibody, 182-D758-040, DSM ACC2747

37G11: mouse monoclonal IgG2a, κ antibody, 182-D1106-055, DSM ACC2737

37H8: mouse monoclonal IgG3, κ antibody, 182-D1106-056, DSM ACC2738

38G5: mouse monoclonal IgG3, κ antibody, 182-D1106-057, DSM ACC2739

38H3: mouse monoclonal IgG3, κ antibody, 182-D1106-058, DSM ACC2740

39F11: mouse monoclonal IgG3, κ antibody, 182-D1106-059, DSM ACC2741

41C6: mouse monoclonal IgG2a, κ antibody, 182-D1106-060

42E12: mouse monoclonal IgG2a, κ antibody, 182-D1106-061, DSM ACC2748

43A11: mouse monoclonal IgG2a, κ antibody, 182-D1106-062, DSM ACC2742

44E10: mouse monoclonal IgG3, κ antibody, 182-D1106-063

47D12: mouse monoclonal IgG3, κ antibody, 182-D1106-064

61C2: mouse monoclonal IgG2b, κ antibody, 182-D1106-067, DSM ACC2743

75B8: mouse monoclonal IgM, κ antibody, 182-D756-001

85A3: mouse monoclonal IgM, κ antibody, 182-D756-002

9E8: mouse monoclonal IgM, κ antibody, 182-D758-011

19B9: mouse monoclonal IgM, κ antibody, 182-D758-024

[0303] Defined as Set2, five hybridoma cell lines were generated, one from a fusion of cells from a Balb/c mouse immunized with CLD18A2-LoopD3 (SEQ ID NOs: 17, 18) and CLD18A2-LoopD1 (SEQ ID NOs: 15, 16), four from a fusion of cells from a Balb/c mouse immunized with CLD18A2-LoopD1 (SEQ ID NOs: 15, 16), expressing the following antibodies:

45C1, 125E1, 163E12, 166E2, 175D10

45C1: mouse monoclonal IgG2a, κ antibody, 182-D758-187

125E1: mouse monoclonal IgG2a, κ antibody, 182-D1106-279, DSM ACC2808

163E12: mouse monoclonal IgG3, κ antibody, 182-D1106-294, DSM ACC2809

166E2: mouse monoclonal IgG3, κ antibody, 182-D1106-308

175D10: mouse monoclonal IgG1, κ antibody, 182-D1106-362, DSM ACC2810

2. Production of Monoclonal Antibodies

[0304] Production and purification of monoclonal antibodies reactive to CLD18:
To produce mg amounts of antibody for functional characterization, hybridoma cells were seeded in dialysis based bioreactors (CELLine CL1000, Integra, Chur, CH) at 2×10^6 cells / ml. Antibody containing supernatant was harvested once weekly. Mouse monoclonal antibody was purified using Melon Gel (Pierce, Rockford, USA) and concentrated by ammonium sulphate precipitation or alternatively purified by ProteinA using FPLC. Antibody concentration and purity was determined by BCA-Assay and purity checked by sodium dodecylsulphate gel electrophoresis and coomassie staining.

3. Binding Characteristics of Monoclonal Antibodies

a. Quality control of transfectants in WB, IF:

[0305] To generate CLD18A2 expressing cells, HEK293 or CHO cells were transfected with nucleic acids encoding CLD18A2 (SEQ ID NOs: 1, 2) or CLD18A2-myc (SEQ ID NOs: 3, 4).

[0306] HEK293 cells were transfected with CLDN18A2-myc (SEQ ID NOs: 3, 4) or left untransfected. 24 hours post transfection, cells were harvested, lysed and subjected to sodium dodecylsulphate gel electrophoresis. The gel was blotted and stained with a mouse anti-myc antibody. After incubation with a peroxidase labelled anti mouse antibody, the blot was developed with ECL reagent and visualized using a LAS-3000 imager (Fuji). Only in the transfected cells but not in the negative control, a band with the expected molecular weight of CLD18-myc was observed (Fig. 2).

[0307] CHO cells were transfected with CLD18A2 (SEQ ID NOs: 1, 2) and grown on chamber slides for 24 h. Cells were fixed with methanol and stained with a rabbit polyclonal antibody against CLD18 at 1 µg/ml for 60 min. at 25°C. After washing, cells were stained with an Alexa488 labelled goat anti-rabbit IgG (Molecular Probes) and evaluated by fluorescence microscopy. Fig. 3 shows transfected CHO cells, expressing CLD18 on the cell membrane as well as untransfected cells. These heterologously CLD18 expressing cells were used for the following assays to test the specificity of antibody binding.

b. Selection of Monoclonal Antibodies Binding to CLD18/Primary Screens by Flow Cytometry:

[0308] HEK293 cells were co-transfected with expression vectors encoding human CLD18A2 (SEQ ID NOs: 1, 2) and a fluorescing reporter protein 40 h prior to the assay or alternatively HEK293 cells stably expressing human CLD18A2 (HEK293-CLD18A2) were used and counterstained with propidium iodide (PI). After cell detachment using 2mM EDTA/PBS cells were washed with complete growth medium and plated at approximately 1-5 × 10^5 cells/well in U-bottom microtiter plates. Cells were incubated for 30 min. at 4° C with hybridoma supernatant followed by two washing steps with 1% heatinactivated FBS/PBS and finally incubation with APC or Alexa647-conjugated anti-mouse IgG specific secondary antibody. After two washing steps, co-transfected cells were fixed with CellFIX (BD Biosciences). Binding was assessed by flow cytometry using a BD FACSArray. Fluorescence marker expression is plotted on the horizontal axis against antibody binding on the vertical axis. All mouse antibodies 24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9, 45C1, 125E1, 163E12, 166E2, and 175D10 were dectected to bind specifically to the surface of fluorescence marker expressing cells (Fig. 4, cells in Q2) as exemplified for hybridoma supernatants containing monoclonal antibodies 24H5 (Fig. 4A, cells in Q2), 85A3 (Fig. 4B), 175D10, 125E1, 163E12, 166E2 and 45C1 (Fig. 4C, cells in Q1).

c. Comparison of antibody binding to Myc- or HA-tagged CLD18A2:

[0309] The binding characteristics of the identified CLD18-specific monoclonal antibodies were further specified. Therefore, monoclonal antibody binding was analyzed to CLD18A2 mutants, created by insertion of epitope tags. CLD18A2-HA (SEQ ID NO: 6) contains a HA-epitope tag in CLD18A2-loop1, whereas CLD18A2-Myc (SEQ ID NO: 4) contains a Myc-epitope tag inserted into CLD18A2-loop2. As insertion of these tags causes destruction of epitopes, the identified monoclonal antibodies, can be grouped according to the loss of binding to any of the mutants. HEK293 cells transiently co-transfected with a fluorescence marker and human CLD18A2, or with a fluorescence marker and CLD18A2-HA, or with a fluorescence marker and CLD18A2-Myc were incubated with hybridoma supernatants containing CLD18-specific monoclonal antibodies for 30 min. at 4°C, followed by incubation with Alexa647-conjugated anti-mouse IgG secondary antibody. Before analysis on a BD FACSArray, cells were fixed using CellFIX. As exemplified for 24H5, 9E8, 26B5 and 19B9 in Fig. 5, monoclonal antibodies could be separated based on their binding characteristics into four different groups: (i) antibodies that bind to unmodified CLD18A2 as well as to CLD18A2-HA and CLD18A2-Myc, e.g. 24H5, (Fig. 5A), or (ii) antibodies that do not bind to CLD18A2-HA, e.g. 9E8, (Fig. 5B), or (iii) antibodies that do not bind to CLD18A2-Myc, e.g. 26B5, (Fig. 5C), or (iv) antibodies that do not bind to CLD18A2-HA nor to CLD18A2-Myc, e.g. 19B9, (Fig. 5D).

d. Comparison of antibody binding to human CLD18A1 versus CLD18A2 transfectants by flow cytometry:

[0310] Binding specificity of the identified monoclonal antibodies to CLD18A2 isoforms was analyzed by flow cytometry. HEK293 cells stably expressing human CLD18A2 (HEK293-CLD18A2) and HEK293 cells stably expressing human CLD18A1 (SEQ ID NOs: 7, 8) (HEK293-CLD18A1) were incubated for 30 min. at 4°C with hybridoma supernatants containing monoclonal antibodies, followed by incubation with Alexa647-conjugated anti-mouse IgG secondary antibody and fixation of cells or alternatively without fixation but with PI counterstaining.

Binding was assessed by flow cytometry using a BD FACSArray. Fig. 6 shows examples for the two groups of monoclonal antibodies that were identified in the panel comprised of 24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9, 45C1, 125E1, 163E12, 166E2, 175D10: (i) monoclonal antibodies 43A11, 45C1, and 163E12 bind specifically to human CLD18A2 but not to human CLD18A1 (Fig 6A,B), and (ii) monoclonal antibody 37H8 binds to both human isoforms (Fig 6A).

e. Comparison of antibody binding to human CLD18A1 versus CLD18A2 transfectants by immunofluorescence microscopy:

[0311] HEK293 cells were transiently transfected with an expression vector encoding a fusion protein of CLD18A1 (SEQ ID NO: 8) or CLD18A2 (SEQ ID NO: 2) with a fluorescence reporter and grown on chamber slides. Cells were either stained unfixed or after paraformaldehyde fixation with monoclonal antibody containing

[0312] tissue culture supernatant for 30 min. at 37°C. After washing, cells were stained with an Alexa555-labelled anti-mouse Ig antibody (Molecular Probes). Binding of antibodies was evaluated by fluorescence microscopy. As shown in Fig. 7, antibody 37G11 specifically reacted with CLD18A2 (Fig. 7A) but not with CLD18A1 (Fig. 7B). In contrast, antibody 26B5 was reactive with both, CLD18A2 and CLD18A1 (Fig. 8).

[0313] For antibodies 24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9, a clear difference between staining of living cells and paraformaldehyde fixed cells was observed. The antibodies formed an uniform membrane staining when cells were fixed (Fig. 7C, 8C, 8D). In contrast, incubation of living cells with these antibodies leads to the generation of protein clusters, visible as a speckle like staining pattern (Fig. 7A, 8A, 8B). This shows that all antibodies bind to native epitopes as found on the surface of living cells.

f. Determination of endogenously expressing cell lines:

[0314] A CLD18A2 gene-specific primer pair (SEQ ID NO: 11, 12) was used in RT-PCR analyses to screen cell lines for expression of CLD18A2. Human gastric carcinoma cell lines NCI-SNU-16 (ATCC CRL-5974), NUGC-4 (JCRB0834) and KATO-III (ATCC HTB-103) and human pancreas adenocarcinoma cell line DAN-G (DSMZ ACC249) were found to display robust endogenous expression of CLD18 (Fig. 9). Expression was confirmed on protein level by staining with a rabbit polyclonal serum against CLD18.

g. Staining of endogenously expressing cell lines with CLD18 specific antibodies and immunofluorescence analysis:

[0315] DAN-G, SNU-16, NUGC-4 and KATO-III cells were grown on chamber slides under standard conditions. Cells were unfixed or alternatively fixed with methanol and stained with the respective antibodies. For antibodies 24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9 staining of the cell surface was observed as exemplified in Fig. 10, 11 and 12A. For antibodies 45C1, 125E1, 163E12, 166E2, and 175D10 native epitope recognition was assayed and cell surface staining was observed on unfixed cells as shown in Fig 12B. Subgroups of antibodies showed homogenous staining of the cell membrane either preponderantly at cell-cell interfaces or at free parts of the membrane not adjacent to other cells. Other antibodies stained discrete foci and aggregates on the cell membrane altogether demonstrating that the respective antibodies bind to different epitopes including epitopes which are masked by homotypic or heterotypic association of CLD18 as well as CLD18 epitopes accessible in preformed tight junctions.

h. Staining of endogenously expressing cell lines by flow cytometry:

[0316] Surface expression of constitutively expressed CLD18A2 on KATO-III and NUGC-4 living cells was analyzed by flow cytometry. This is exemplified by KATO-III and NUGC-4 cells stained with monoclonal antibody 61C2 or 163E12, followed by incubation with Alexa647-conjugated anti-mouse IgG secondary antibody and fixation of cells or alternatively without fixation. Binding was assessed by flow cytometry using a BD FACSArray. Fig. 13 shows a strong binding of 61C2 to at least 70.3% of KATO-III cells and of 163E12 to CLD18A2 on KATO-III and NUGC-4 cells.

i. Sequence alignment of mouse and human CLD18A1 and CLD18A2:

[0317] Human CLD18A2 (NP_ 001002026) and human CLD18A1 (NP_057453) in a sequence comparison differ in the N-terminus and mouse CLD18 variants (NP_062789 and AAL15636) demonstrate high homology and sequence variation sites between the molecules (see Fig. 14).

j. Reactivity of antibodies with murine CLD18A1 and murine CLD18A2 analyzed by flow cytometry:

[0318] Binding of the identified monoclonal antibodies to murine CLD18A2 and CLD18A1 was analyzed by flow cytometry. HEK293 cells transiently co-transfected with a fluorescence marker and murine CLD18A2 (SEQ ID NOs: 33, 35) or with a fluorescence marker and murine CLD18A1 (SEQ ID NOs: 36, 37) were incubated with hybridoma supernatants containing the human CLD18-specific monoclonal antibodies 38G5, 38H3, 37G11, 45C1 and 163E12, respectively, for 30 min. at 4°C, followed by incubation with Alexa647-conjugated anti-mouse IgG secondary antibody and fixation of cells. Binding was assessed by flow cytometry using a BD FACSArray. Fig. 15 shows three different binding profiles: 38G5, and 45C1 do not bind to any of the murine CLD18 isoforms, 37G11, and 163E12 bind to murine CLD18A2 but not to murine CLD18A1, and 38H3 binds to murine CLD18A1 and CLD18A2. These antibodies are valuable tools to determine a potential toxicity of CLD18 monoclonal antibodies in preclinical studies.

[0319] Altogether these data show, that monoclonal antibodies of the teaching 24H5, 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, 61C2, 75B8, 85A3, 9E8, 19B9, 45C1, 125E1, 163E12, 166E2, and 175D10 generated against CLD18 represents a diversity of binding characteristics to different epitopes and topologies of human CLD18.

[0320] A combination of different properties described in examples 3b, c, d, e, g, h, and j can be used to categorize monoclonal antibodies into such different classes.

4. Immunohistochemistry (IHC)

[0321] A CLD18A2 epitope specific antibody generated by immunization with the peptide of SEQ ID NO: 21 was used for immunohistochemical characterisation of CLD18A2 expression. Paraffin embedded tissue sections derived from a comprehensive panel of normal and tumor tissues were used for protein expression and localisation analyses. No significant expression was detected in any other normal organ tissue except stomach (see Tab. 2, Fig. 16A). In contrast, CLD18A2 expression was verified by immunohistochemistry in different cancers including stomach cancer and lung cancer (Fig. 16B).

[0322] Interestingly, expression of CLD18A2 protein in gastric mucosa was restricted to terminally differentiated cells of the gastric epithelium in the base and pit regions. In contrast, cells in the neck region of gastric mucosa, in particular gastric stem cells in the isthmus part, which replenish the entire mucosa, do not express CLD18A2 (Fig. 16C).

Tab. 2: CLD18A2 expression in normal and tumor tissues as analysed by IHC

Tissue type	Result
Adrenal	-
Bladder	-
Blood cells	-
Bone Marrow	-
Breast	-
Colon	-
Endothelium	-
Esophagus	-
Fallopian tube	-
Heart	-
Kidney (glomerulus, tubule)	-
Liver	-
Lung	-
Lymph node	-
Ovary	-
Pancreas	-
Parathyroid	-
Pituitary	-
Placenta	-
Prostate	-
Skin	-
Spleen	-
Stomach	+
Striated muscle	-
Testis	-
Thymus	-
Thyroid	-
Ureter	-
Uterus (cervix, endometrium)	-

[0323] The monoclonal antibody 39F11 was used for immunohistochemical CLD18A2 specific studies. As shown in Fig. 17A, no significant reactivity was detectable on all tested normal tissues except stomach (Fig. 17A), whereas stomach carcinomas and lung carcinomas remain strongly positive (Fig. 17B).

[0324] Another group of antibodies of the teaching shows a specific cancer staining pattern with binding to stomach cancer but no reactivity with normal stomach tissue. Such a staining pattern is shown in Fig. 18A with monoclonal antibody 26B5.

[0325] Immunohistochemistry was used for specificity analysis of 175D10 (Fig. 18B), 43A11 (Fig. 18C), 163E12 (Fig.18D) and 45C1 (Fig. 18E) on sections derived from HEK293 tumor cell lines: HEK293 tumor cell lines stably expressing human CLD18A2 (HEK293-CLD18A2) or CLD18A1 (HEK293-CLD18A1) or being transfected with an expression control plasmid containing only the antibiotic resistence gene for selection (HEK293-mock) were xenografted into mice to form solid tumors. No expression was detectable in mock-transfected HEK293 xenograft tumors. In contrast, strong and homogeneous membran-staining was observed in HEK293-CLD18A2 xenograft

tumors and in stomach carcinoma specimens.

5. Complement Dependent Cytotoxicity (CDC)

a. CDC of monoclonal antibodies of Set1 as measured by flow cytometry:

[0326] Plasma for complement lysis was prepared by drawing blood from healthy volunteers into S-Monovette-EDTA vacutainer tubes (Sarstedt, Nürmbrecht, Germany) which were then centrifuged at 600 g for 20 min. Plasma was harvested and stored at -20°C.

[0327] In a first set of experiments hybridoma supernatants were analyzed for their capability to induce complement dependent cytotoxicity (CDC) against HEK293 cells stably expressing human CLD18A2 (HEK293-CLD18A2). Cells were incubated with hybridoma supernatants containing monoclonal antibodies 85A3, 28D10, 24H5 or 26D12, respectively for 20 min. at room temperature. Following centrifugation (5 min. at 450 g) the supernatant was removed and 20% human plasma in DMEM (prewarmed to 37°C) was added to the cells and incubated for another 20 min. at 37°C. Thereafter, cell lysis was determined on FACS by using the propidium iodide (PI) staining method. PI was added to a final concentration of 2.5 µg/ml. For flow cytometry, a BD FACSArray flow cytometer was used (BD Biosciences, Mountain View, CA). At least 10000 events were collected for analysis with cell debris excluded by adjustment of the forward sideward scatter (FCS) threshold. The percentage of lysed cells (PI-positive cells) is shown in Figure 19. Monoclonal antibodies 85A3, 28D10 and 26D12 induced lysis of 33.5%, 38.2% and 39.2%, respectively of HEK293-CLD18A2 cells, whereas CDC mediated by 24H5 was only 19.3%.

b. CDC of monoclonal antibodies of Set1:

[0328] In a second set of experiments the specificity of monoclonal antibodies to induce CDC on CLD18A2 expressing cells was analyzed. Therefore, a set of antibodies binding either specific to human CLD18A2 or also binding to human CLD18A1 was tested for CDC-induction against CHO cells stably transfected with human CLD18A2 (CHO-CLD18A2) or human CLD18A1 (CHO-CLD18A1). CHO-CLD18A2 and CHO-CLD18A1 cells were seeded 24 h before the assay with a density of 3×10^4/well in tissue-culture flat-bottom microtiter plates. The next day growth medium was removed and the cells were incubated in triplicates with hybridoma supernatants adjusted to a concentration of 10 µg/ml containing monoclonal antibodies 24H5, 26D12, 28D10, 37G11, 37H8, 38G5, 38H3, 39F11, 41C6, 42E12, 43A11, 44E10, 47D12, and 61C2, respectively. Control cells were incubated with growth medium or growth medium containing 0.2% saponin for the determination of background lysis and maximal lysis, respectively. After incubation for 20 min. at room temperature supernatant was removed and 20% human plasma in DMEM (prewarmed to 37°C) was added to the cells and incubated for another 20 min. at 37°C. Then, supernatants were replaced by PBS containing 2.5 µg/ml ethidium bromide and fluorescence emission after excitation at 520 nm was measured using a Tecan Safire. The percentage specific lysis was calculated as follows: % specific lysis = (fluorescence sample - fluorescence background) / (fluorescence maximal lysis - fluorescence background) × 100. Fig. 20 shows that monoclonal antibodies 26D12, 28D10, 37H8, 38H3 and 39F11 mediate high, monoclonal antibody 38G5 mediates medium, monoclonal antibodies 41C6 and 61C2 mediate low, and monoclonal antibodies 24H5, 37G11, 42E12, 43A11, 44E10 and 47D12 mediate no CDC against CHO-CLD18A2 cells. In contrast, none of the antibodies is capable of inducing CDC against CHO-CLDA1 cells, although 26D12, 28D10, 37H8, 38H3, 39F11, 41C6, 47D12 and 61C2 also bind to CLD18A1 as determined by flow cytometry and immunofluorescence.

c. Monoclonal antibody titration and CDC using monoclonal antibodies of Set1:

[0329] To measure the ability of the anti-CLD18 antibodies to induce CDC at low concentrations, an experiment was performed where three different antibodies were titrated. CHO-CLD18A2 cells growing in microtiter plates were incubated with a concentration range of 75B8 (100, 30, 10, 3 and 1 µg/ml), 37H8 (10, 3.3 and 1 µg/ml) and 28D10 (10, 1 and 0.1 µg/ml), respectively, for 20 min. at room temperature. Supernatant was removed and 20% human plasma in DMEM (prewarmed to 37°C) was added to the cells and incubated for another 20 min. at 37°C. Before analysis using a Tecan Safire, supernatants were replaced by PBS containing 2.5 µg/ml ethidium bromide. Figures 21A-C show the percentage of specific lysis as a function of antibody concentration. Monoclonal antibody 75B8 induces lysis of 31.0% CHO-CLD18A2 cells at 10 µg/ml, and drops to 6.2% at 1 µg/ml (Fig. 21A), whereas monoclonal antibodies 28D10 and 37H8 still induce 39% and 26.5% specific lysis at 1 µg/ml (Fig. 21B, C), respectively.

d. CDC of monoclonal antibodies of Set2 as measured by flow cytometry:

[0330] Serum for complement lysis was prepared by drawing blood from healthy volunteers into Serum-Monovette vacutainer tubes (Sarstedt, Nürmbrecht, Germany) which were then centrifuged at 600 g for 20 min. Serum was harvested and stored at -20°C. Control serum was heat inactivated at 56°C for 30 min before storage.

[0331] Hybridoma supernatants were analyzed for their capability to induce complement dependent cytotoxicity (CDC) against KATO-III cells endogenously expressing human CLD18A2. Cells were incubated with crude or purified hybridoma supernatants containing monoclonal antibodies 45C1, 125E1, 163E12, 166E2, and 175D10, respectively for 30 min. at 37°C. 20% human serum in RPMI was added to the cells and incubated for another 30 min. at 37°C. Thereafter, cell lysis was determined on FACS by using the propidium iodide (PI) staining method. PI was added to a final concentration of 2,5 µg/ml. For flow cytometry a BD FACSArray flow cytometer was used (BD Biosciences, Mountain View, CA). At least 10000 events were collected for analysis with cell debris excluded by adjustment of the forward sideward scatter (FSC/SSC) threshold. Specific lysis was calculated by the following formula: specific lysis = (% PI-positive cells in sample - % PI-positive cells in sample with heat inactivated serum). Robust CDC mediated lysis was observed in particular for 163E12.

6. Antibody-Dependent Cellular Cytotoxicity (ADCC)

[0332] Hybridoma supernatants were analyzed for their capability to induce antibody-dependent cellular cytotoxicity (ADCC) against HEK293 cells stably expressing human CLD18A2 (HEK293-CLD18A2) or human CLD18A1 (HEK293-CLD18A1).

1. a. Enrichment of human peripheral blood mononuclear cells: Human blood from healthy donors was diluted twice in phosphate buffer (PBS) and blood cells were layered on Ficoll (Lymphocyte Separation Medium 1077 g/ml, PAA Laboratories, cat. no. J15-004). Peripheral blood mononuclear cells (MNCs) were collected from the interphase, washed and resuspended in RPMI 1640 culture medium supplemented with 10% heat-inactivated fetal calf serum, 2 mM L- glutamine.
2. b. ADCC set up: Target cells were labeled with with a fluorescence enhancing ligand (BADTA, Perkin Elmer cytotoxicity assay kit DELFIA EuTDA Cytotoxicity Reagents, cat. no. AD0116) for 30 minutes. After extensive washing in RPMI-10 supplemented with 10 mM probenecid (Sigma, cat. no. P8761), 10-20 mM HEPES, and 10% heat-inactivated fetal calf serum, the cells were adjusted to 1×10^5 cells/ml. Labeled target cells, effector cells (MNCs), and supernatants containing monoclonal antibodies adjusted to a concentration of 10 µg/ml were added to round-bottom microtiter plates. For isolated effector cells, an effector to target (E:T) ratio of 100:1 (data not shown for 50:1 and 25:1) was used. After incubation (2 hours, 37°C), assays were stopped by centrifugation, and fluorescence ligand release from duplicates was measured in europium counts in a time-resolved fluorometer. Percentage of cellular cytotoxicity was calculated using the following formula: % specific lysis = (experimental release counts - spontaneous release counts) / (maximal release counts - spontaneous release counts) × 100, with maximal fluorescence ligand release determined by

adding Triton X-100 (0,25% final concentration) to target cells, and spontaneous release measured in the absence of antibodies and effector cells. Figure 22 shows that monoclonal antibodies 26B5, 37H8, 38G5, 47D12, and 61C2 mediate ADCC against HEK293-CLD18A2 cells. In contrast, these antibodies induce no significant or only low level cytotoxicity on CLD18A1 targets demonstrating a CLD18A2 specific ADCC (Figure 23).

7. Proliferation Inhibition

[0333] Purified murine monoclonal antibodies were analyzed for their capability to inhibit cell growth of KATO-III cells endogenously expressing human CLD18A2.

[0334] 1×10^4 target cells endogenously expressing CLD18A2 (KATO-III) were cultured in the presence of approximatly 10µg monoclonal antibodies.

[0335] DELFIA Cell Proliferation Kit (Perkin-Elmer, Cat. No. AD0200) is a non-isotopic immunoassay based on the measurement of 5-bromo-2'-deoxyuridine (BrdU) incorporation during DNA synthesis of proliferating cells in microplates. Incorporated BrdU is detected using europium labelled monoclonal antibody. To allow antibody detection cells are fixed and DNA denatured using Fix solution. Unbound antibody is washed away and DELFIA inducer is added to dissociate europium ions from the labelled antibody into solution, where they form highly fluorescent chelates with components of the DELFIA Inducer. The fluorescence measured - utilizing time-resolved fluorometry in the detection - is proportional to the DNA synthesis in the cell of each well.

[0336] Strong inhibition of proliferation was observed with antibodies 125E1, 163E12, 45C1, 37G11, 37H8, 28D10 and 166E2, respectively.. Moderate inhibition of proliferation was observed with murine antibodies 43A11, 175D10, 42E12, 26D12, 61C2 and 38H3, respectively.

8. Performance in therapeutic mouse xenograft models

[0337] Therapeutic potential of the identified monoclonal antibodies binding specifically to CLD18A2 was studied in therapeutic xenograft models.

a. Early treatment of highly CLD18A2 expressing tumors in mice

[0338] SCID mice were subcutaneously inoculated with 1×10^7 HEK293 cells stably expressing high levels of human CLD18A2 (HEK293-CLD18A2). Expression levels of human CLD18A2 in HEK293-CLD18A2 cells were comparable with expression levels in primary gastric cancers from patients. Each experimental treatment group comprised 10 mice (number of mice per group n=10). Therapy of mice started 3 days after tumor inoculation. 200 µg of purified hybridoma supernatants representing murine monoclonal antibodies 26B5, 26D12, 28D10, 37G11, 37H8, 38G5, 39F11, 42E12, 43A11, 38H3, or 61C2 were injected once per week for 4 weeks intravenously. Alternatively 200 µg of purified hybridoma supernatants containing murine monoclonal antibodies 45C1, 125E1, 163E12, 166E2, or 175D10 were administered twice per week for 6 weeks by alternating intravenous and intraperitoneal injection. Tumor growth of treated mice was monitored twice per week (Tumor Volume = Length × Width × Width divided by 2 in mm^3). The mice were killed if the tumor reached a volume of 500 mm^3 or in case of severe morbidity. Fig. 24 exemplifies robust inhibition of HEK293-CLD18A2 tumor cell growth by antibodies of the teaching. Fig. 25A and 25B show prolongation of survival by treatment with antibodies of the teaching in an early treatment xenograft model using HEK293-CLD18A2 cells.

b. Late onset treatment of advanced highly CLD18A2 expressing tumors in mice

[0339] The same tumor xenograft model based on HEK293-CLD18A2 cells was designed as a late therapy onset protocol as opposed to the early treatment described above. On day 27 after tumor cell inoculation mice were randomized in test groups each comprising 5-6 mice and therapy was initiated with 200 µg of purified hybridoma supernatants containing murine monoclonal antibodies 43A11, 163E12, and 175D10, respectively. Antibodies were administered twice per week for 6 weeks by alternating intravenous and intraperitoneal injection. Also in this model antibodies of the teaching were shown to inhibit tumor growth. For several antibodies this resulted in prolongation of survival (Fig. 26).

c. *Early treatment of tumors expressing low levels of CLD18A2*

[0340] SCID mice were subcutaneously inoculated with 2×10^5 cells of the DAN-G tumor cell line, an infiltrating human pancreatic adenocarcinoma cell line that constitutively expresses CLD18A2 protein at low level. Treatment of mice (10 per group) was initiated 3 days after tumor grafting: 200 µg of purified hybridoma supernatants containing murine monoclonal antibodies 45C1, 125E1, 163E12, 166E2, or 175D10 were administered twice per week for 6 weeks by alternating intravenous and intraperitoneal injection. Owing to the aggressive and fast tumor growth of the pancreatic DAN-G tumor cell line in vivo mice developed tumor cachexia and died within a few days. Even though, as a consequence, the window for measuring therapeutic effects was narrow, tumor growth inhibition and prolonged survival mediated by antibodies of the teaching was also observed in this model (Fig. 27A and 27B).

d. Antibodies of the teaching do not elicit side effects in mice

[0341] A murine CLD18A2-specific primer pair (s: CTA CCA AGG GCT ATG GCG TTC, as: GCA CCG AAG GTG TAC CTG GTC) was used in RT-PCR analyses to amplify cDNA derived from a comprehensive panel of normal mouse tissues (see Fig. 28).

[0342] Expression of murine CLD18A2 was not detectable in any tested normal tissues, except stomach (see Fig. 28). Furthermore, an CLD18A2 specific antibody, which crossreacts with human and mouse CLD18A2, was used for immunohistochemical analysis of CLD18A2 expression in a large panel of normal mouse tissues (see Tab. 3). Except for normal gastric tissue all tested normal tissues show no CLD18A2 expression. As we observed for the human CLD18A2, we also found for the mouse counterpart that while the surface epithelia- and deeper crypt cells express CLD18A2 at their cell surface, the central neck region is CLD18A2 negative (see Fig. 29 A-C). In summary, tissue distribution of CLD18A2 appears to be identical in men and mice.

Tab. 3: CLD18 expression within murine normal tissues as analysed by immunhistochemistry

tissue	CLD18 expression
cerebellum	-
cerebrum	-
colon	-
esophagus	-
heart	-
kidney	-
liver	-
lung	-
lymph node	-

tissue	CLD18 expression
ovary	-
pancreas	-
skeletal muscle	-
spleen	-
stomach	+
thymus	-
bladder	-

[0343] We further investigated potential side effects mediated by antibodies 125E1, 163E12, 166E2 and 175D10 in mice. All of these antibodies had been previously shown by FACS analysis to react with the murine CLD18A2 as well as with the human protein.

[0344] Neither were any visible side effects observed in mice during and after treatment with these antibodies, nor were any histomorphological correlates of toxicity observed in the gastric mucosa of antibody treated mice as compared to untreated (PBS- treated) mice (see Figure 30).

e. Early treatment of highly CLD18A2 expressing tumors in mice with chimeric monoclonal antibodies

[0345] Similar to example 8 a but using chimeric monoclonal antibodies, early treatment of highly CLD18A2 expressing tumors in mice with antibodies of the teaching was assessed. Briefly, SCID mice were subcutaneously inoculated with 1×10^7 HEK293 cells stably expressing high levels of human CLD18A2 (HEK293-CLD18A2). Each experimental treatment group comprised 10 mice. Therapy of mice started 3 days after tumor inoculation. 200 µg of purified cell culture supernatants of HEK293T cells transiently transfected to produce chimeric monoclonal antibodies ch-163E12 or ch-175D10 (cf. example 9, below) were administered twice per week for 6 weeks by alternating intravenous and intraperitonal injection. Robust inhibition of HEK293-CLD18A2 tumor cell growth by chimeric antibodies of the teaching could be observed. Fig. 34 shows prolongation of survival by treatment with chimeric antibodies of the teaching in an early treatment xenograft model using HEK293-CLD18A2 cells.

f. Late onset treatment of advanced highly CLD18A2 expressing tumors in mice with chimeric monoclonal antibodies

[0346] The same tumor xenograft model based on HEK293-CLD18A2 cells as described above was designed as a late therapy onset protocol as opposed to the early treatment described above. On day 8 after tumor cell inoculation mice were randomized in test groups each comprising 9 mice and therapy was initiated with 200 µg of purified cell culture supernatants of HEK293T cells transiently transfected to produce chimeric monoclonal antibodies ch-163E12 or ch-175D10 (cf. example 9, below). Antibodies were administered twice per week for 6 weeks by alternating intravenous and intraperitoneal injection. Also in this model chimeric antibodies of the teaching were shown to inhibit tumor growth. For several chimeric antibodies this resulted in prolongation of survival (Fig. 35).

9. Chimerization of antibodies

a. Generation of mouselhuman chimeric monoclonal antibodies

[0347] Total RNA and subsequently single stranded cDNA was prepared from human peripheral blood mononuclear cells (PBMC) and from human spleen tissue by standard methods known to those skilled in the art, for example by using RNeasy Midi Kit (Qiagen) and Superscript II reverse transcriptase (Invitrogen).

[0348] The constant region of the human kappa light chain was amplified from PBMC cDNA by PCR. The sense oligomer (SEQ ID NO:38) added a BamHI restriction site at the 5' end of the constant region and changed the original nucleic acid sequence 5'-CGAACT-3' coding for the first two amino acids (Arg-Thr) of the constant region into 5'-CGTACG-3', generating a BsiWI restriction site without changing the amino acid sequence. The antisense oligomer (SEQ ID NO:39) included a stop codon and added a NotI restriction site at the 3' end of the amplified constant region. The PCR product as well as a standard expression vector (for example pcDNA3.1(+), Invitrogen) were sequentially incubated with BamHI and NotI restriction enzymes. The vector was additionally treated with calf intestinal alkaline phosphatase to prevent recirculation. The constant region was finally ligated into the vector, so that any forthcoming fusion of a variable region in front of the constant region is now possible via a HindIII restriction site (5'-AAGCTT-3') from the residual vector multiple cloning site and via the BsiWI restriction site (5'-CGTACG-3') generated with the PCR product. The sequence of the human kappa light chain constant region inserted into the vector is listed as SEQ ID NO:40, the amino acid sequence of the human kappa constant region is listed as SEQ ID NO:41.

[0349] The constant region of the human gamma-1 heavy chain was amplified from spleen cDNA by PCR. The 5' phosphorylated sense oligomer (SEQ ID NO:42) was placed over the naturally occurring ApaI restriction site, located 11 nucleotides downstream of the beginning of the constant region, and added a HindIII restriction site at the 5' end of the amplified part of the constant region. The 5' phosphorylated antisense oligomer (SEQ ID NO: 43) included a stop codon and added a NotI restriction site at the 3' end of the thus amplified constant region. The thus generated PCR product was blunt ended and 5' phosphorylated. The amplified gamma constant region was verified to be of the IgG1 subclass by PCR with a discriminating antisense oligomer (SEQ ID NO: 44) and by sequencing. A standard expression vector (for example pcDNA3.1(+)/Hygro, Invitrogen) with a different antibiotic resistance (for example hygromycin) than that of the vector used for expression of the light chain (for example neomycin) was incubated with PmeI restriction enzyme to completely remove the multiple cloning site leaving blunt ends. The vector was additionally treated with calf intestinal alkaline phosphatase to prevent recirculation. The constant region was finally ligated into the vector, so that any forthcoming fusion of a variable region in front of the constant region is now possible via the HindIII restriction site (5'-AAGCTT-3') and via the ApaI restriction site (5'-GGGCCC-3'), both generated with the PCR product. The correct orientation of the constant region in the vector, i.e. suitable for the preceeding promoter of the vector, was verified by sequencing. Due to the position of the ApaI restriction site, any amplification of a variable region for this purpose has to include the first 11 nucleotides of the sequence of the human gamma-1 constant region in addition to the sequence of the ApaI site. The sequence of the thus amplified human gamma-1 heavy chain constant region inserted into the vector is listed as SEQ ID NO:45, the amino acid sequence of the thus expressed human gamma-1 constant region is listed as SEQ ID NO: 46.

Tab. 4: mouse hybridoma cell lines used for antibody cloning

	clone	mAb	Isotype	variable region	oligomer pair in PCR	chimerized antibody
heavy chain						
	43A11	182-D1106-062	IgG2a	SEQ ID NO:55, 132	SEQ ID NO:70, 71	SEQ ID NO:100, 115
	163E12	182-D1106-294	IgG3	SEQ ID NO:56, 133	SEQ ID NO:72, 73	SEQ ID NO:101, 116
	125E1	182-D1106-279	IgG2a	SEQ ID NO:57, 134	SEQ ID NO:74, 75	SEQ ID NO:102, 117
	166E2	182-D1106-308	IgG3	SEQ ID NO:59, 136	SEQ ID NO:78, 79	SEQ ID NO:104, 119
	175D10	182-D1106-362	IgG1	SEQ ID NO:58, 135	SEQ ID NO:76, 77	SEQ ID NO:103, 118

	clone	mAb	Isotype	variable region	oligomer pair in PCR	chimerized antibody
	45C1	182-D758-187	IgG2a	SEQ ID NO:60, 137	SEQ ID NO:80,81	SEQ ID NO:105, 120
light chain						
	43A11	182-D1106-062	IgK	SEQ ID NO:62, 139	SEQ ID NO:84, 85	SEQ ID NO:107, 122
	163E12	182-D1106-294	IgK	SEQ ID NO:61, 138	SEQ ID NO:82, 83	SEQ ID NO: 106, 121
	125E1	182-D1106-279	IgK	SEQ ID NO:63, 140	SEQ ID NO:86, 87	SEQ ID NO:108, 123
	166E2	182-D1106-308	IgK	SEQ ID NO:66, 143	SEQ ID NO:92, 93	SEQ ID NO:111, 126
	175D10	182-D1106-362	IgK	SEQ ID NO:65, 142	SEQ ID NO:90, 91	SEQ ID NO: 110, 125
	45C1	182-D758-187	IgK	SEQ ID NO:64, 141	SEQ ID NO:88, 89	SEQ ID NO:109, 124
	45C1	182-D758-187	IgK	SEQ ID NO:67, 144	SEQ ID NO:94, 95	SEQ ID NO:112, 127
	45C1	182-D758-187	IgK	SEQ ID NO:68, 145	SEQ ID NO:96, 97	SEQ ID NO:113, 128
	45C1	182-D758-187	IgK	SEQ ID NO:69, 146	SEQ ID NO:98, 99	SEQ ID NO:114, 129

[0350] Corresponding to their murine counterparts the chimeric monoclonal antibodies were named adding the prefix "ch-" e.g. ch-43A11, ch-163E12, ch-125E1, ch-166E2, ch-175D10, ch-45C 1.

[0351] Amplification of the murine variable regions of light and heavy chains was carried out according to the "step-out PCR" method described in Matz *et al.* (Nucleic Acids Research, 1999, Vol. 27, No. 6). For this, total RNA was prepared from monoclonal hybridoma cell lines (see Tab. 4) by standard methods known to those skilled in the art, for example with the use of RNeasy Mini Kit (Qiagen). Single stranded cDNA was prepared according to the "template-switch" method also described in Matz *et al.* (Nucleic Acids Research, 1999, Vol. 27, No. 6, 1558). In addition to an (dT)30 oligomer (SEQ ID NO: 47), it included a DNA/RNA hybrid oligomer (SEQ ID NO: 48) serving as an 5' adaptor for template switching during polymerization of the cDNA strand. In this adaptor oligomer the last three nucleotides were ribo- instead of deoxyribonucleotides. The subsequent "step-out PCR" used an antisense oligomer targeted to the constant region of the mouse kappa chain or to the constant region of the subclasses 1, 2a or 3 of the gamma chains (SEQ ID NO: 49 to 52, respectively). The IgG subclass of the murine monoclonal antibody produced by the hybridoma cell lines was afore immunologically analyzed with IsoStrip (see Example 1), and the appropriate antisense oligomer was chosen accordingly (see Tab. 4). A primer mix served as the sense oligomer in the "step-out PCR", comprising the two oligomers listed in SEQ ID NO: 53 and 54. Some hybridoma cell lines expressed more than one heavy or light chain (in addition to the chains expressed by the myeloma cell line used for the generation of hybridomas). Table 4 summarizes the SEQ ID NOs of the cloned and sequenced variable regions of the murine antibody chains (SEQ ID NO: 55 to 69 and SEQ ID NO: 132 to 146) and of the cloned and sequenced full-length chimieric antibody chains (SEQ ID NO: 100 to 129).

[0352] The identified murine variable regions were then amplified by PCR omitting the 5' UTR and the 3' mouse constant region, adding restriction sites to the ends which allowed subcloning into the prepared expression vectors carrying the human constant regions. In addition, the sense oligomers provided a consensus Kozak sequence (5'-GCCGCCACC-3' or 5'-AGCCACC-3') and the antisense oligomers for heavy chain variable regions included the first 11 nucleotides of the human gamma-1 constant region in addition to the ApaI restriction site (see Tab. 4, SEQ ID NO: 70 to 99). Kappa light chain variable regions were cloned using HindIII and BsiWI restriction enzymes,

gamma heavy chain variable regions demanded HindIII and ApaI restriction enzymes. The heavy gamma chain variable region of monoclonal antibody 45C1 contained an internal HindIII restriction site - here, the compatible BsaI enzyme was used instead (see SEQ ID NO: 80). SEQ ID NO: 100 to 114 show the nucleic acid sequences of the resulting chimerized antibodies (see Tab. 4). SEQ ID NO: 115 to 129 show the amino acid sequences of the accordingly expressed chimerized antibodies (see Tab. 4).

b. Generation and production of chimeric antibodies against CLD18

[0353] Mammalian cell lines producing chimeric antibodies with CLD18 specificity were generated. The cell lines derived from HEK293T cells (ATCC CRL-11268). One day before transfection, 2.5×10^7 cells were plated in a 14.5 cm tissue culture dish and cultured in 20 ml of complete medium, or alternatively 1×10^7 cells were plated in a 10 cm tissue culture dish and cultured in 10 ml of complete medium, or alternatively 0.6×10^6 cells were plated in a well of a 12-well tissue plate and cultured in 2-3 ml of complete medium (complete medium: DMEM:F12 medium supplemented with 10% FBS without antibiotics). The recommended cell density at the time of transfection should be 90% confluence. Immediately before transfection, medium was replaced by fresh medium. HEK293T cells were transfected with transfection reagents, e.g. Lipofectamine 2000 (Invitrogen, 11668-019) or alternatively Polyethylenimine (Sigma-Aldrich, 408727). Exemplified for transfection of HEK293T cells a total DNA amount of 110 µg or 296 µg was used for a 14.5 cm tissue dish, and the ratio of transfection agent to DNA was 1:2.5 and 1:12 for Lipofectamine 2000 and PEI, respectively. 24 h after transfection medium was replaced with a GMP suitable medium, e.g. X-Vivo 15 (Cambrex) or a chemical defined medium like Pro293a (Cambrex) without serum. Transfected HEK293T cells producing chimeric monoclonal antibodies against CLD18 were cultured for further 96 h. Crude supernatants were harvested, sterile filtered and purified by protein A-sepharose. Antibody concentration was determined by BCA Assay and purity checked by sodium dodecylsulphate gel electrophoresis and coomassie staining.

c. Binding Characteristics of Chimeric Monoclonal Antibodies

[0354] Binding specificity of the cloned and generated chimeric monoclonal antibodies to CLD18A2 was analyzed by flow cytometry as described in Example 3. HEK293 living cells stably expressing human CLD18A2 (HEK293-CLD18A2) and HEK293 cells stably expressing human CLD18A1 (SEQ ID NOs: 7, 8) (HEK293-CLD18A1) were incubated for 30 min. at 4°C with purified HEK293T cell culture supernatants containing chimeric monoclonal antibodies, followed by incubation with APC-conjugated $F(ab')_2$ fragment goat anti-human IgG Fcγ secondary antibody and counterstained with PI. Binding was assessed by flow cytometry using a BD FACSArray.

[0355] Similarly, endogenously CLD18A2 expressing human tumor cell lines, for example KATO-III and NUGC-4 cells, were analyzed by flow cytometry.

[0356] Fig. 31A and B show flowcytometric analyses of chimeric antibodies ch-43A11, ch-125E1, ch-163E12, ch-166E2, and ch-175D10. All of them show native epitope recognition and exhibit specific and strong binding to CLD18A2 but not CLD18A1 expressing cells.

d. Complement Dependent Cytotoxicity (CDC)

[0357] Serum for complement lysis was prepared by drawing blood from healthy volunteers into Serum-Monovette vacutainer tubes (Sarstedt, Nürmbrecht, Germany) which were then centrifuged at 600 g for 20 min. Serum was harvested and stored at -20°C. Control serum was heat inactivated at 56°C for 30 min before storage.

[0358] Protein A-sepharose-purified chimeric antibodies of this teaching were analyzed for their capability to

induce complement dependent cytotoxicity (CDC) against KATO-III cells endogenously expressing human CLD18A2, as well as stably transfected CHO-CLD18A2 cells. Cells were incubated with monoclonal antibodies ch-163E12, ch-166E2, and ch-175D10, respectively, in a final concentration of 2.5 µg/ml to 35 µg/ml for 30 min. at 37°C. 20% human serum in RPMI was added to the cells and incubated for another 30 min. at 37°C. Thereafter, dead and living cells were discriminated by PI staining in a final concentration of 2.5 µg/ml and percentage of antibody-mediated cell lysis was determined by flow cytometry. For flow cytometric analysis a BD FACSArray flow cytometer was used (BD Biosciences, Mountain View, CA). At least 10000 events were collected for analysis with cell debris excluded by adjustment of the forward sideward scatter (FSC/SSC) threshold. Specific lysis was calculated by the following formula: specific lysis = (% PI-positive cells in sample - % PI-positive cells in sample with heat inactivated serum). Specific lysis mediated by CDC was shown for several antibodies. All three antibodies mediated robust CDC on CHO-CLD18A2 cells (Figure 32). On KATO-III cells antibodies ch-163E12 and ch-175D10 were inducers of robust CDC.

e. Antibody-Dependent Cellular Cytotoxicity (ADCC)

[0359] FPLC-purified, chimeric antibodies of the teaching were analyzed for their capability to induce antibody-dependent cellular cytotoxicity (ADCC) against KATO-III cells endogenously expressing human CLD18A2.

[0360] Human blood from healthy donors was diluted twice in phosphate buffer (PBS) and blood cells were layered on Ficoll (1077 g/ml, Pharmacia). After centrifugation, peripheral blood mononuclear cells (PBMC) were collected from the interphase, washed and resuspended in X-Vivo-15 culture medium supplemented with 5% heat-inactivated human serum.

[0361] 15h before the assay, KATO-III cells were transfected with luciferase and plated at 5×10^4 cells/well in a white microplate.

[0362] For the assay, effector cells (PBMC, prepared as described above) at an effector to target (E:T) ratio of 20:1 and FPLC-purified chimeric antibodies were added and incubated for 2 - 3h at 37°C, 5% CO_2. Final concentration of the antibody in the well was 50µg/ml. After 2-3h of pre-incubation, lucifer yellow (BD Biosciences, San Jose USA) was added at 1mg/ml. Luminescence resulting from the oxidation of lucifer yellow by the luciferase of viable cells was measured continually for up to 6h using a microplate-reader (Infinite200, Tecan, Switzerland). Percentage of cellular cytotoxicity was calculated using the following formula: % specific lysis = 100-((sample luminescence counts - spontaneous luminescence counts) / (maximal luminescence counts - spontaneous luminescence counts) × 100), with the spontaneous luminescence determined by adding Triton X-100 (0,2% final concentration), and the maximal signal measured in the absence of antibodies.

[0363] Using this assay it was shown that monoclonal antibodies ch-163E12 and ch-175D10 mediate strong ADCC on KATO-III cells (Fig. 33).

f. Proliferation Inhibition

[0364] FPLC-purified chimeric antibodies of the teaching were analyzed for their capability to inhibit cell growth of KATO-III cells endogenously expressing human CLD18A2.

[0365] Target cells (KATO-III) were cultured in the presence of chimeric respective antibodies (see proliferation inhibition of murine antibodies, Example 7). FPLC purified chimeric antibodies ch-163E12 and ch-166E2 were shown to inhibit cell proliferation.

10. Selection of antibodies as clinical lead candidates

[0366] Ideal clinical leads may cover a wide range of therapeutic and diagnostic applications (see also section IV - Uses and Methods of the Teaching). According to the teaching antibodies directed to CLD18-A2 are provided. It is shown that the antibodies provided according to the teaching offer a broad spectrum of properties regarding specificity, ability to induce CDC and ADCC and inhibit proliferation of cells expressing CLD18, in particular tumor cells. Furthermore, it has been demonstrated that chimerisation of antibodies may lead to the aquisition of additional Fc-dependent effector functions not present in the parental murine molecule. For example, it is shown herein that antibody 175D10 with murine IgG1 does not induce complement dependent cytotoxicity (see Example 5), while ch-175D10 with human IgG1 induces specific lysis of constitutively CLD18 expressing tumor cells (see Tab. 5 and Tab. 6).

[0367] Antibodies provided according to the present teaching may be categorized into distinct classes according to their binding properties and their ability to mediate effector functions on cells expressing CLD18. From the antibodies provided according to the present teaching, clinical lead candidates may be selected based on their functional characteristics. An overview of properties for selected murine and chimeric antibodies of the teaching is given in Tab. 5 and Tab. 6, respectively.

[0368] Clinical lead candidates of the teaching may have one or more of the following properties:

1. a) binding to human CLD18A2 but not to human CLD18A1 (e.g. 43A11, 45C1, 125E1, 163E12, 166E2 and 175D10, and ch-43A11, ch-45C1, ch-125E1, ch-163E12, ch-166E2 and ch-175D10). For examples, see figures 6A and 6B.
2. b) binding to mouse CLD18A2 but not to mouse CLD18A1 (e.g. 125E1, 163E12, 166E2 and 175D10). For examples, see figures 15A and 15B.
3. c) binding to CLD18 naturally expressed by tumor cells (e.g. 45C1, 43A11, 125E1, 163E12, 166E2 and 175D10, and ch-45C1, ch-43A11, ch-125E1, ch-163E12, ch-166E2 and ch-175D10). For examples, see figure 13
4. d) binding to CLD18 in intercellular contact zones (e.g. 45C1, 43A11, 125E1, 163E12, 166E2 and 175D10). For examples, see figures 12A and 12B.
5. e) mediating CDC induced killing of cells, which express CLD18 (e.g. 45C1, 125E1, 163E12, 166E2 and 175D10, and ch-163E12 and ch-175D10). For examples, see figure 32.
6. f) mediate ADCC induced killing of cells expressing CLD18 (e.g. ch-163E12 and ch-175D10). For examples, see figure 33.
7. g) inhibiting proliferation of cells expressing CLD18 (e.g. 45C1, 125E1, 163E12, 166E2 and 175D10, and ch-163E12 and ch-166E2).
8. h) inhibiting tumor growth in xenograft models with cells expressing CLD18 (e.g. 43A11, 125E1, 163E12, 166E2, and 175D10). For examples, see figure 24.
9. i) prolonging survival in xenograft models with cells expressing CLD18 (e.g. 43A11, 125E1, 163E12, 166E2 and 175D10). For examples, see figure 25B.

Exemplary overview of properties for lead candidate selection

[0369]

Table 5: murine antibodies

antibody	binding of human CLD18A2 but not A1	binding of mouse CLD18A2 but not A1	binding of CLD18 on naturally expressing tumor cells	binding to CLD 18 in contact zones	mediating CDC on CLD18 expressing cells	inhibiting proliferation of cells expressing CLD 18	inhibiting tumor growth in xenograft expressing CLD 18	prolonging survival in xenograft expressing CLD 18
45C1	+	-	+	+	(+)	+	(+)	(+)
125E1	+	+	+	+	(+)	+	+	+
163E12	+	+	+	+	+	+	+	+
175D10	+	+	+	+	(+)	(+)	+	+
legend: + excellent performance, (+) performance in different setups.								

Table 6: chimeric antibodies

antibody	binding of human CLD18A2 but not A1	binding of CLD18 on naturally expressing tumor cells	mediating CDC on CLD18 expressing cells	mediating ADCC on CLD 18 expressing cells	inhibiting proliferation of cells expressing CLD 18
ch-45C1	+	+	n.d.	n.d.	n.d.
ch-125E1	+	+	n.d.	n.d.	n.d.
ch-163E12	+	+	+	+	+
ch-175D10	+	+	+	+	n.d.
legend: + excellent performance, (+) performance in different setups, n.d. not done.					

11. Epitope analysis

[0370] Mapping of epitopes recognized by antibodies of teaching can be performed as described in detail in "Epitope Mapping Protocols (Methods in Molecular Biology) by Glenn E. Morris ISBN-089603-375-9 and in "Epitope Mapping: A Practical Approach" Practical Approach Series, 248 by Olwyn M. R. Westwood, Frank C. Hay.

[0371] Briefly, for epitope mapping peptide scans can be created by synthetic overlapping peptides (prepared by SPOT-Synthesis) derived from the amino acid sequence of the antigen. The peptide scan membrane can be washed with TBS, blocked with 10% milk/Tween 20-TBS and incubated with antibodies of the teaching conjugated with peroxidase overnight at 4°C diluted in 5% milk/Tween 20-TBS, followed by washing with Tween20-TBS and TBS, developed with e.g. ECL Lumi-Light (Roche) and detected by a Lumi Imager.

a. Molecular Epitope Analysis

[0372] The first extracellular domain (ECD1) of human CLD18 shows a high degree of homology between both isoforms with only 8 positions in the amino acid sequence accounting for the difference (see Fig. 14).

[0373] Monoclonal antibodies were selected that selectively recognize only the stomach-specific isoform CLD18A2 (see example 1). In order to determine critical amino acids out of those that differ in both isoforms, amino acid substitutions were created in the CLD18 proteins by exchanging amino acids in one isoform with those found at the corresponding positions in the other isoform. Specifically, eight variants were generated, wherein in each variant one of the eight amino acids in CLD18A2 ECD1 differing to the amino acid sequence of CLD18Al was replaced with the amino acid found at the corresponding position in CLD18A1. Three CLD18A2 variants were

generated, wherein in each variant 2 amino acids were replaced with the amino acids found at the corresponding positions in CLD18A1: the second and third, the third and fourth, and the fourth and the fifth amino acids of those 8 amino acids. The corresponding 11 constructs for the other isoform CLD18A1 were generated by replacing the respective amino acids in CLD18A1 with those found in CLD18A2.

[0374] The altered CLD18 proteins were generated by mutating nucleic acid coding for the respective CLD18 isoform and cloning the mutated nucleic acids into a standard expression vector.

[0375] Reduced binding of the antibodies tested towards the CLD18A2 variants generated and increased binding towards the CLD18A1 variants generated were monitored by flow cytometric analysis. Unmodified wildtype CLD18A1 and CLD18A2 were also included in the analysis.

[0376] To this end, HEK293 cells were transiently transfected with nucleic acids encoding wildtype CLD18A1 or CLD18A2 or the mutant variants thereof to generate human CLD18A1 or CLD18A2 expressing cells. Transfectants were incubated with the tested antibodies of teaching and binding characteristics analyzed by flow cytometry.

[0377] Mouse monoclonal antibody **44** E4 D3 F11 (182-D1106-179, IgG2a, κ) recognizes both CLD18A1 and CLD18A2 on the cell surface. Antibody ch-175D10 showed strong, specific binding to wildtype CLD18A2 (see Tab. 7). Antibody ch-175D10 does not bind to CLD18A2 variants 3, **4** and 6 having the following amino acid substitutions: variant 3: A**4**2S; variant **4**: N**4**5Q; variant 6: E56Q. Also no binding to the CLD18A2 double variants containing at least one of the single amino acid substitutions of variants 3 and **4** was observed.

Tab. 7: Mutagenesis overview and results

		Wildtype sequence		Mutagenesis of CLD18 A2											Mutagenesis of CLD18 A1										
Domain	Position	CLD18 A1	CLD18 A2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ECD1	29	M	Q	M											Q										
ECD1	37	D	N		D							D				N							N		
ECD1	42	S	A			S						S	S				A						A	A	
ECD1	45	Q	N				Q						Q	Q				N							N	N
ECD1	47	E	Q					E						E					Q						Q
ECD1	56	Q	E						Q											E					
ECD1	65	P	G							P											G				
ECD1	69	I	L								I											L			
Binding of ch 175 D10 to:		-	+	+	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Binding of 44 E4 D3 F11 to:		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

b. Epitope Mapping via Peptide Scan

[0378] In order to identify and to map the epitope recognized by the antibodies of teaching, a peptide scan was created by synthetic overlapping peptides (prepared by SPOT-Synthesis) derived from the amino acid sequence of the first extracellular domain of CLD18A2. The entire antigen sequences were synthesized by Jerini AG, Berlin, Germany as linear 15meric peptides (with overlap of 11 amino acids) and subsequently tested for binding by antibodies of the teaching. Additionally, all cysteines of the linear peptides were substituted by serines in order to avoid the formation of disulphide bonds between linear peptides. Chimeric monoclonal antibodies of the teaching were conjugated with peroxidase according to the manufacture's instructions (Pierce, EZ-Link Plus Activated Peroxidase Kit) and incubated with the peptide scan. Specific epitope recognition towards CLD18A2 was monitored by luminescence. In Tab. 8 the binding intensity of the chimeric monoclonal antibodies ch-175D10 and

ch-163E12 to the synthetic peptides derived from the amino acid sequence of the first extracellular domain of CLD18A2 are shown.

Tab. 8: Specific binding and epitope recognition of chimeric antibodies to CLD18 A2

antibody		MDQWSTQDLYNNPVT	STQDLYNNPVTAVFN	LYNNPVTAVFNYQGL	PVTAVFNYQGLWRSC	VFNYQGLWRSCVRES	QGLWRSCVRESSGFT	RSCVRESSGFTECRG
	Peptide	1	2	3	4	5	6	7
	SEQ ID NO:	151	152	153	154	155	156	157
ch-175D10	No exchange	++					+	+++
	Cys-Ser exchange	++					+	+
ch-163E12	No exchange	+++		+++		+++	+++	
	Cys-Ser exchange	+++		+++		+++	+++	

[0379] Both Antibodies ch-175D10 and ch-163E12 recognize a discontinuous (conformational) epitope with at least two binding sites indicating that the key amino acid residues are distributed over two or more binding regions which are separated in the primary protein structure. Upon folding, these binding regions are brought together on the protein surface to form a composite epitope. Strong binding of antibody ch-175D10 to peptides 1 and 7 with no cysteine exchange, but slight binding to peptide 7 containing serines instead of the two cysteines, indicates the central role of the cysteines for epitope recognition and probably protein folding (Fig. 36). Our data suggest three different protein folding models for the first extracellular domain of CLD18A2 containing the epitope for both chimeric antibodies (Fig. 37). The first model shown in Fig. 37 represents linear peptide 7 containing both cysteines, the second model shows an intramolecular disulphide bond resulting in a loop, and the third model describes two cysteines forming two intermolecular disulphide bonds.

12. Determination of antibody affinity

[0380] For determination of binding constants via Scatchard analysis, the binding of antibodies of the teaching to human CLD18A2 can be titrated on HEK293 cells stably expressing CLD18A2 and analyzed by flow cytometry. Human or chimeric antibodies of teaching can be detected by a sandwich of unconjugated mouse-anti-human IgG and FITC-conjugated goat-anti-mouse IgG. Each antibody incubation step can be performed for 30 min at 4°C followed by 2 washes in FACS buffer. Murine antibodies of the teaching can be directly detected with the secondary antibody goat-anti-mouse conjugated with FITC. The sandwich detection of antibodies of the teaching using secondary and tertiary antibodies might be necessary to quantitate the number of bound antibodies of the teaching by using the QIFIKIT kit (DAKO, Glostrup, Denmark). With this kit the number of bound antibody can be determined by flow cytometry according to the manufacturer's instructions. A strictly linear relationship of mean fluorescence intensity and bound IgG can be obtained. Data can be analysed by Scatchard plotting and by KD determination directly from the binding curves. The dissociation constants can be calculated according to Krause et al., Behring Inst. Mitt. 87: 56-67, 1990 and Nauendorf et al., Int J Cancer 100: 101-120, 2002.

[0381] According to the teaching, dissociation constants for antibodies of teaching were determined by a flow

cytometric-based binding assay using HEK293-CLD18A2 cells stably expressing CLD18A2. Scatchard analysis of cell binding data yielded a range of dissociation constants from 10^{-8} M to 10^{-9} M for murine and chimeric 175D10 and 163E12. The dissociation constants were calculated according to Krause et al., Behring Inst. Mitt. 87: 56-67, 1990 and Nauendorf et al., Int J Cancer 100:101-120, 2002.

13. Orthologous cross-reactivity

[0382] Binding to human and murine CLD18A2 and CLD18A1 was analyzed by flow cytometry. HEK293 cells transiently co-transfected with a fluorescence marker and murine CLD18A2 (SEQ ID NOs: 33, 35), or with a fluorescence marker and murine CLD18A1 (SEQ ID NOs: 36, 37), or with a fluorescence marker and human CLD18A2 (SEQ ID NOs: 1, 2), or with a fluorescence marker and human CLD18A1 (SEQ ID NOs: 7, 8) were incubated with ch-175D10, ch-163E12 and ch-125E1 for 30 min. at 4°C, followed by incubation with allophycocyanin coupled anti-human IgG secondary antibody (30 min. 4°C).

[0383] Fig. 38 shows the binding profile for the antibodies ch-175D10, ch-163E12 and ch-125E1. These antibodies are valuable tools to determine a potential toxicity of CLD18 monoclonal antibodies in preclinical studies, as described in example 3j for their murine counterparts.

14. CLD18A2 shows high plasma membrane expression in primary gastric tumors and gastric cancer metastases

[0384] Unselected specimen from primary gastric cancer and gastric cancer metastasis (Krukenberg tumors & lymph nodes) were stained with GC182 specific rabbit antiserum. Immunohistochemistry as well as evaluation of staining intensity (neg, weak=1, moderate=2, strong=3) and proportion of tumor cells showing a plasma membrane staining (0-100%) was performed by professional clinical pathologists; see. Fig. 39. In Fig. 39, each circle respresents an independent tumor specimen. Statistically significant increased staining intensity was observed in metastases (p=0,034, Fisher's exact test).

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PATENTKAV

1. Fremgangsmåde til påvisning af metastatiske cancerceller fra en gastrisk cancer, omfattende at bringe en prøve opnået fra en Krukenberg-tumor eller en prøve opnået fra lymfeknuderne, og en kontrolprøve, i kontakt med et antistof, der specifikt binder til Claudin-18-splejningsvariant 2 (CLD18A2), under forhold, der muliggør dannelse af et kompleks mellem antistoffet eller en antigenbindingsdel deraf og CLD18A2, hvor en øget mængde af kompleksdannelse i prøven indikerer metastatiske celler i prøven.

2. Fremgangsmåde ifølge krav 1, hvor de metastatiske cancerceller er celler fra en Krukenberg-tumor.

3. Farmaceutisk sammensætning omfattende et antistof og/eller et konjugat, der omfatter antistoffet koblet til et terapeutisk middel, og en farmaceutisk acceptabel bærer, til anvendelse i en fremgangsmåde til behandling af en gastrisk cancermetastase,

hvor antistoffet kan binde til CLD18A2 og mediere eliminering af celler, der udtrykker CLD18A2 ved induktion af komplementafhængigt cytotoksicitets- (CDC) medieret lyse eller ved induktion af antistofafhængig cellulær cytotoksicitet- (ADCC) medieret lyse og/eller hæmning af proliferation af celler, der udtrykker CLD18A2.

4. Farmaceutisk sammensætning til anvendelse ifølge krav 3, hvor antistoffet binder til Claudin-18-splejsningsvariant 1 (CLD18A1) og CLD18A2.

5. Farmaceutisk sammensætning til anvendelse ifølge krav 3, hvor antistoffet binder til CLD18A2, men ikke til CLD18A1.

6. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-5, hvor eliminering af celler og/eller hæmning af proliferation induceres ved binding af antistoffet til CLD18A2 udtrykt af cellerne.

7. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-6, hvor eliminering af celler og/eller hæmning af proliferation ikke induceres af binding af antistoffet til CLD18A1 udtrykt af cellerne.

8. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-7, hvor antistoffet ikke inducerer CDC-medieret lyse af cellerne.

9. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-8, hvor den ADCC-medierede lyse finder sted i tilstedeværelse af effektorceller valgt fra gruppen bestående af monocytter, mononukleære celler, NK-celler og PMN'er.

10. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-9, hvor antistoffet er et monoklonalt, kimærisk eller humaniseret antistof, eller et antigenbindingsfragment af et antistof.

11. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-10, hvor antistoffet vælges fra gruppen bestående af et IgG1-, et IgG2-, IgG2a- og IgG2b-, et IgG3-, et IgG4-, et IgM-, et IgA1-, et IgA2-, et sekretorisk IgA-, et IgD- og et IgE-antistof.

12. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-11, hvor CLD18A2 har aminosyresekvensen ifølge SEQ ID NO: 2.

13. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 4-12, hvor CLD18A1 har aminosyresekvensen ifølge SEQ ID NO: 8.

14. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-13, hvor antistoffet er specifikt for mavecancerceller.

15. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-14, hvor CLD18A2 udtrykkes på cellernes overflade.

16. Farmaceutisk sammensætning omfattende et antistof, der binder til CLD18A2 og/eller et konjugat omfattende antistoffet koblet til et terapeutisk middel, og en farmaceutisk acceptabel bærer, til anvendelse i en fremgangsmåde til behandling af en gastrisk cancermetastase,

hvor antistoffet frembringes af en klon, der er indleveret under accessionsnummer DSM ACC2737, DSM ACC2738, DSM ACC2739, DSM ACC2740, DSM ACC2741, DSM ACC2742, DSM ACC2743, DSM ACC2745, DSM ACC2746, DSM ACC2747, DSM ACC2748, DSM ACC2808, DSM ACC2809 eller DSM ACC2810.

17. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-16, hvor det terapeutiske middel er et toksin, en radioisotop, et lægemiddel eller et cytotoksisk middel.

18. Farmaceutisk sammensætning til anvendelse ifølge et hvilket som helst af kravene 3-17, hvor den gastriske cancermetastase er en metastase i lymfeknuderne.

DRAWINGS

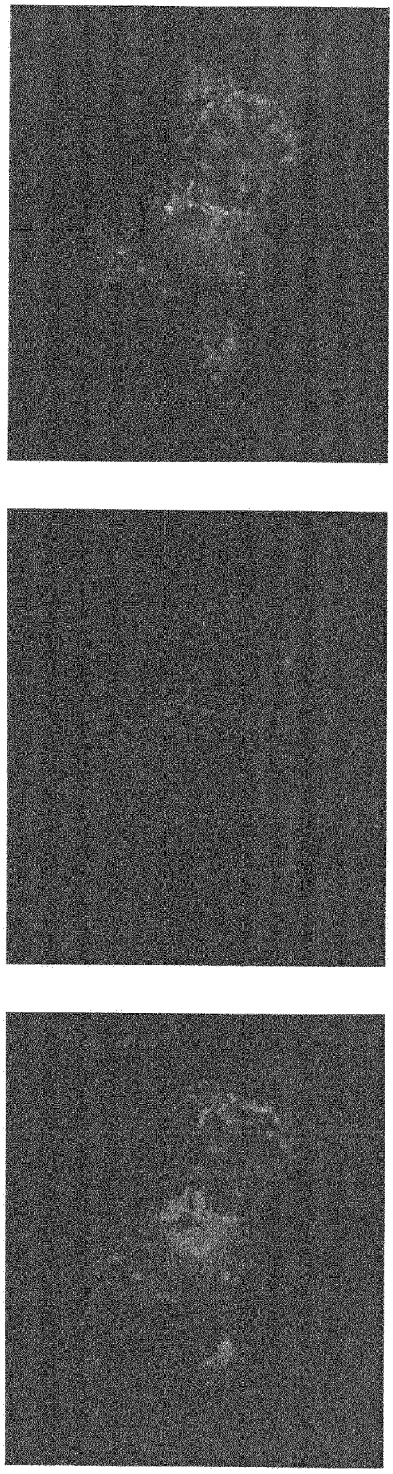


Fig. 1

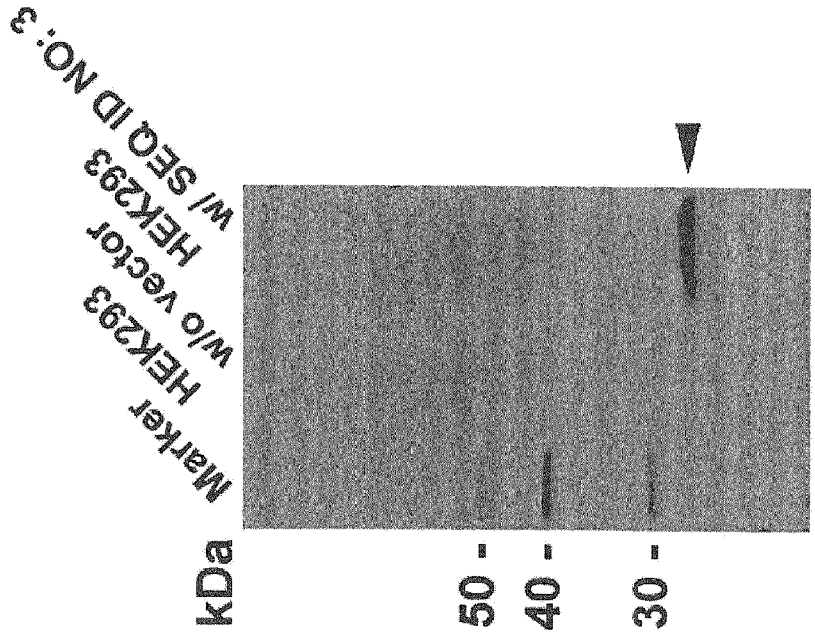


Fig. 2



Fig. 3

Fig. 4

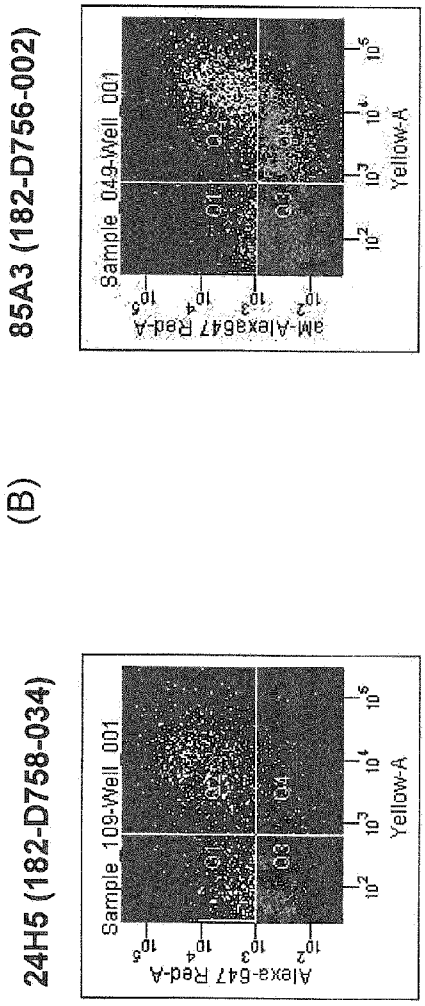

(A)
24H5 (182-D758-034)
Sample_109-Well_001
Alexa-647 Red-A
Yellow-A
Q1
Q2
Q3
Q4
(B)
85A3 (182-D756-002)
Sample_049-Well_001
am-Alexa647 Red-A
Yellow-A
Q1
Q2
Q3
Q4

Fig. 4C

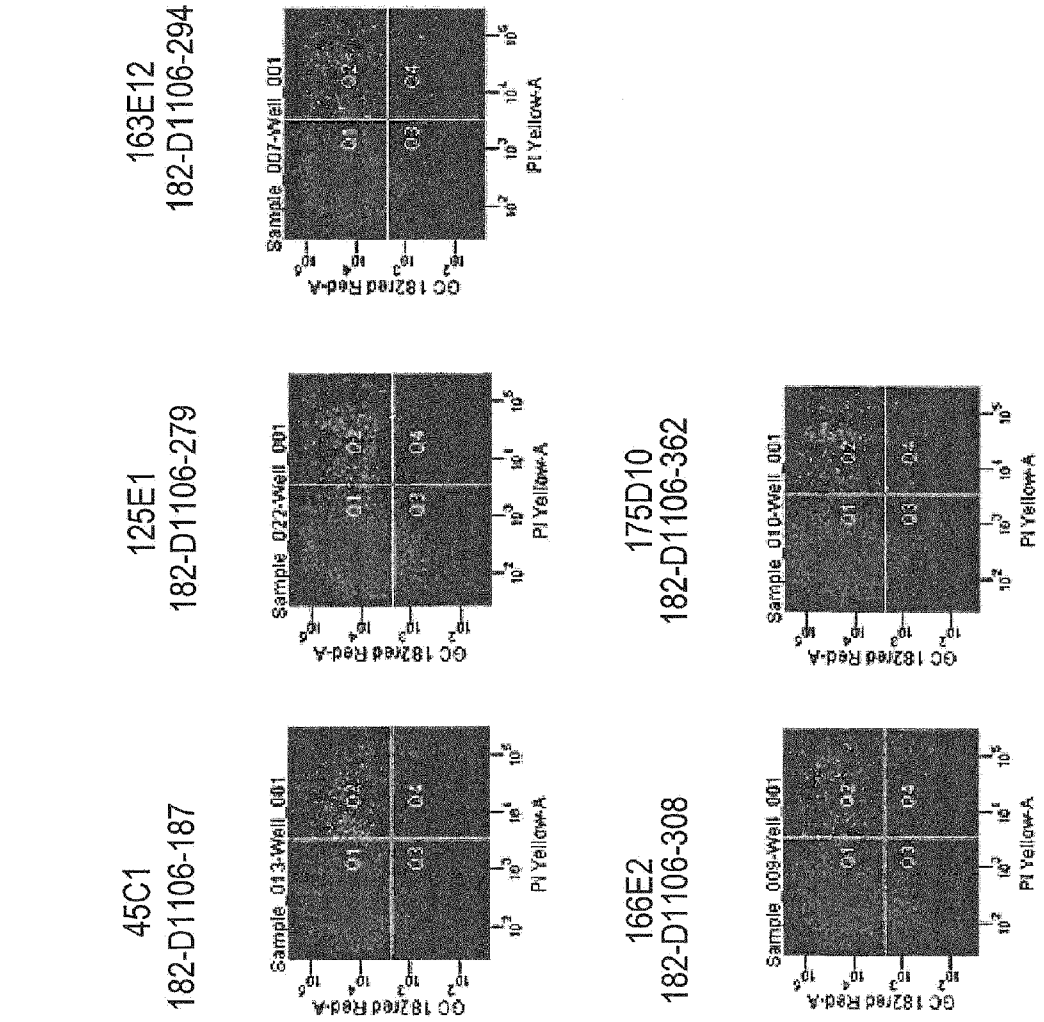

45C1
182-D1106-187
125E1
182-D1106-279
163E12
182-D1106-294
175D10
182-D1106-362
166E2
182-D1106-308
HEK293-huCLD18A2
HEK293-huCLD18A2
Sample_013-Well_001
Sample_022-Well_001
Sample_007-Well_001
Sample_010-Well_001
Sample_009-Well_001
GC 18Zred Red-A
PI Yellow-A

Fig. 5

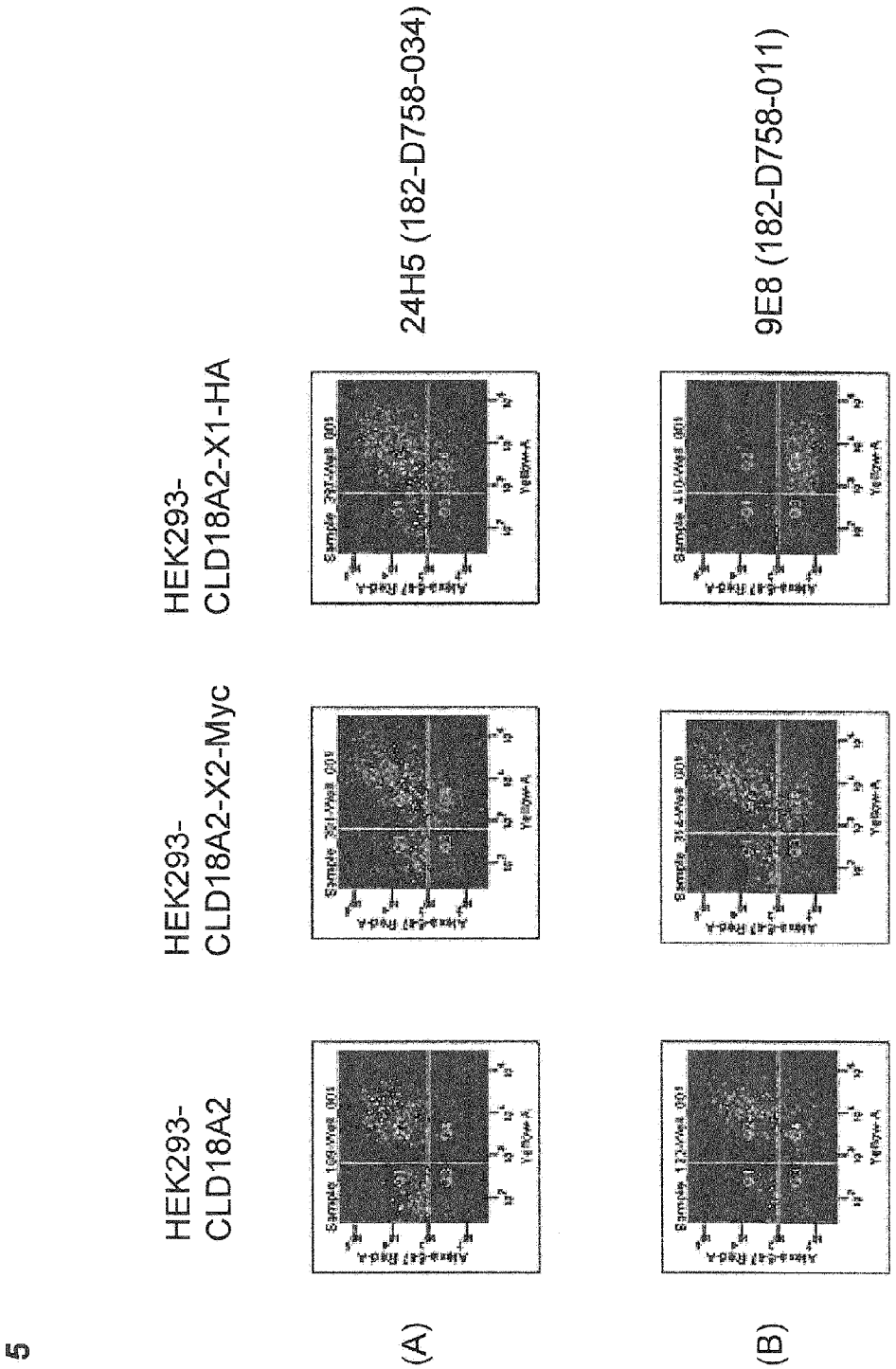
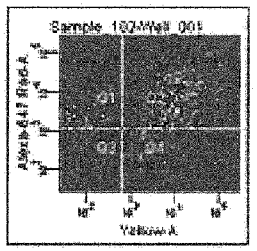
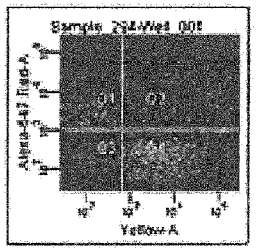
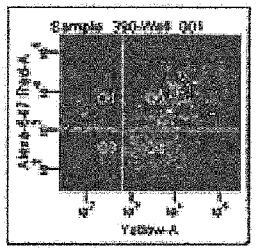
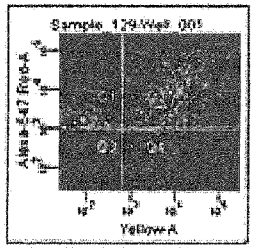
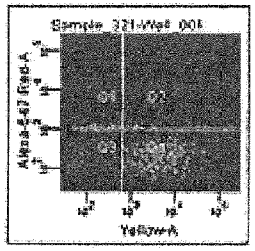
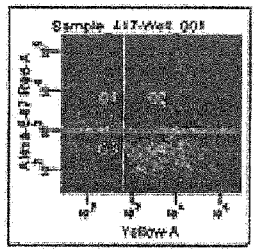
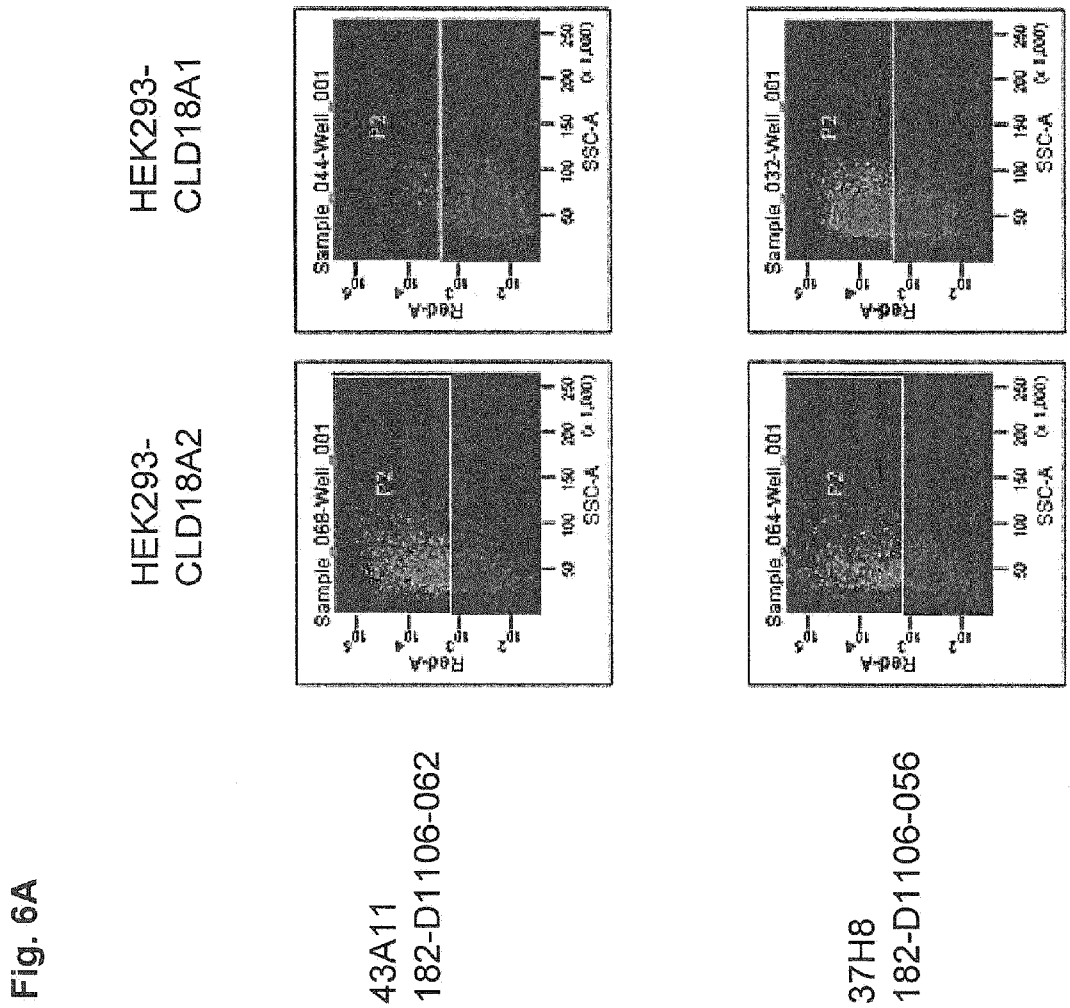

HEK293-CLD18A2
HEK293-CLD18A2-X2-Myc
HEK293-CLD18A2-X1-HA
24H5 (182-D758-034)
9E8 (182-D758-011)
(A)
(B)

Fig. 5

	HEK293-CLD18A2	HEK293-CLD18A2-X2-Myc	HEK293-CLD18A2-X1-HA	
(C)				26B5 (182-D758-035)
(D)				19B9 (182-D758-024)

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Fig. 6A


HEK293-CLD18A2
HEK293-CLD18A1
Sample_068-Well_001
Sample_044-Well_001
Sample_064-Well_001
Sample_032-Well_001
P2
Red-A
SSC-A
43A11
182-D1106-062
37H8
182-D1106-056

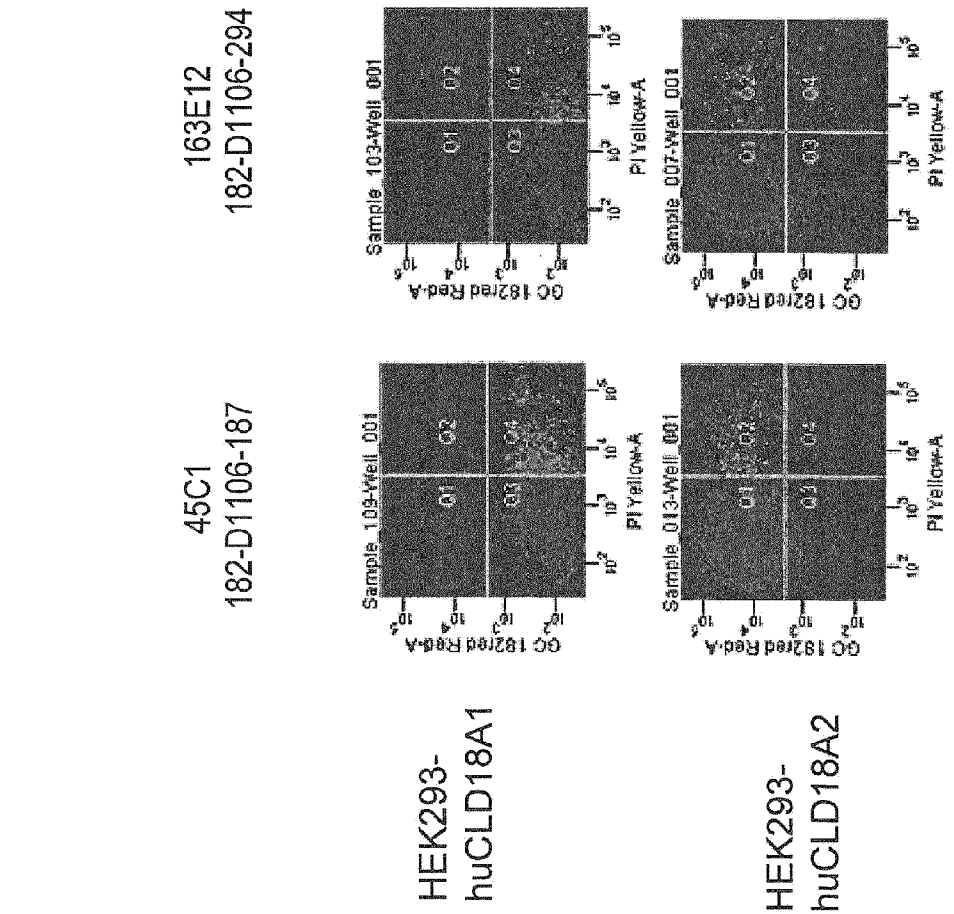
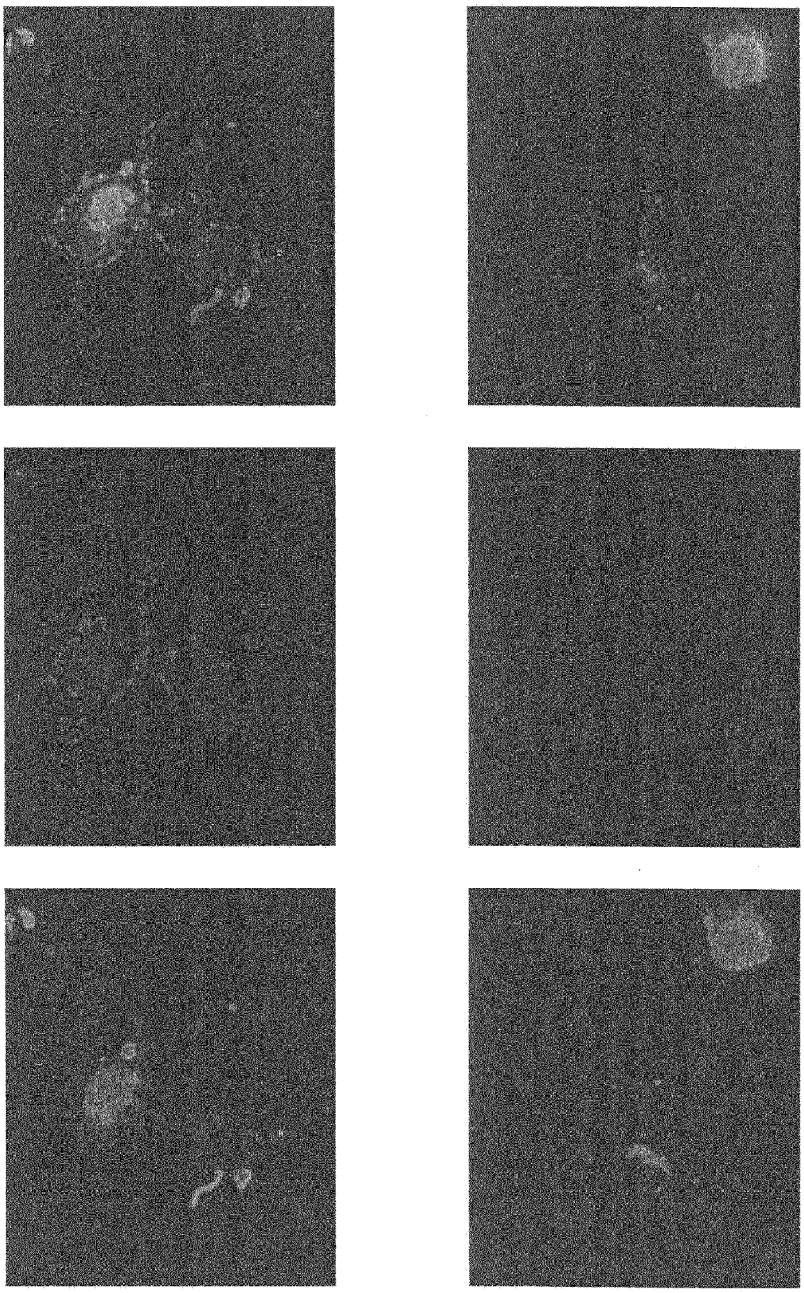
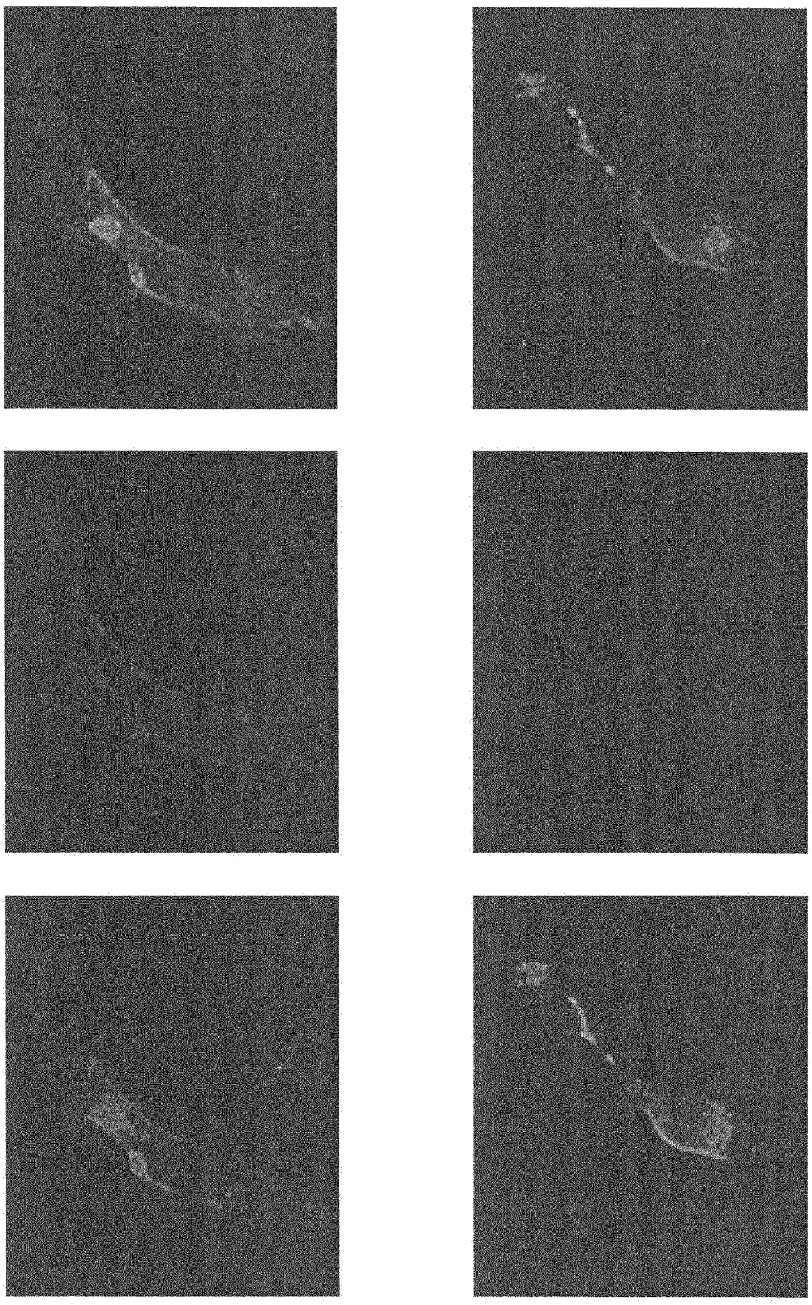

163E12
182-D1106-294
45C1
182-D1106-187
HEK293-huCLD18A1
HEK293-huCLD18A2
Sample_103-Well_001
Sample_109-Well_001
Sample_007-Well_001
Sample_013-Well_001
PI Yellow-A
GC 18Zred Red-A
Q1
Q2
Q3
Q4

Fig. 6B



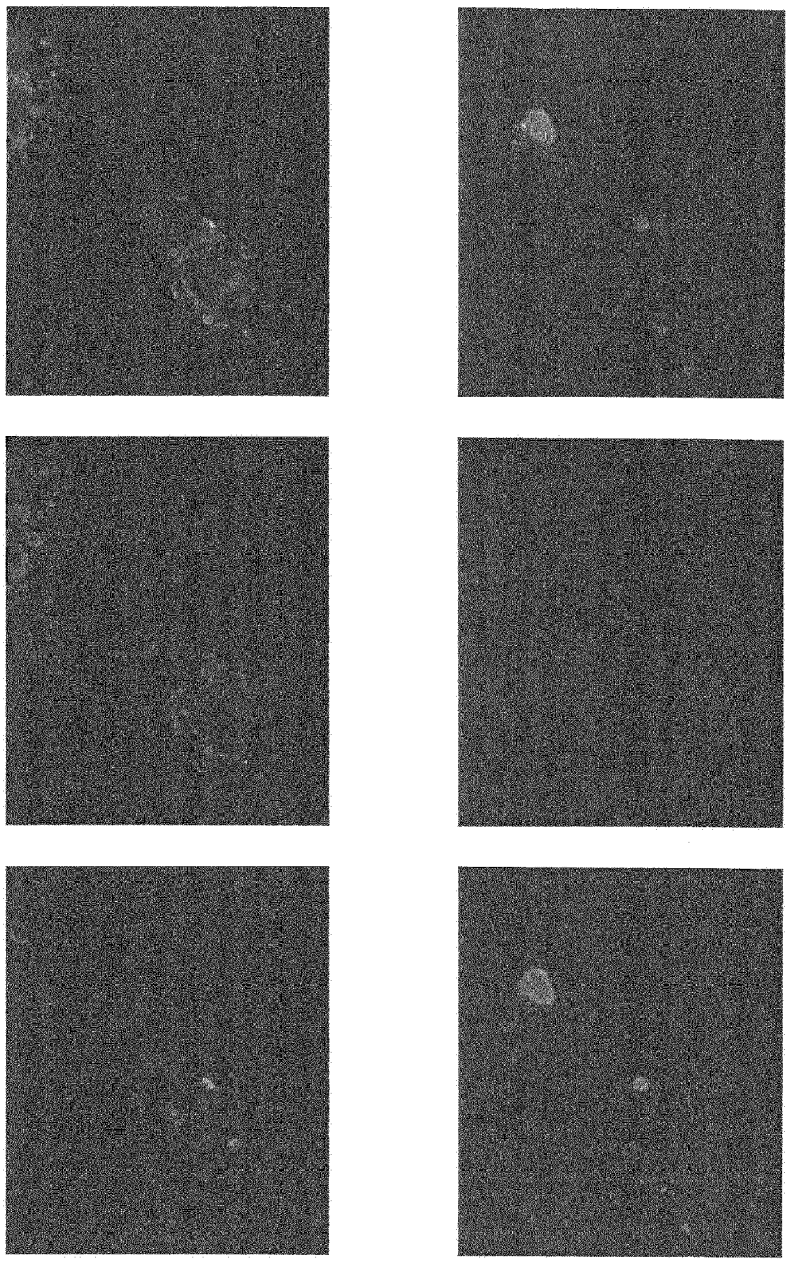
(A) (B)

Fig. 7



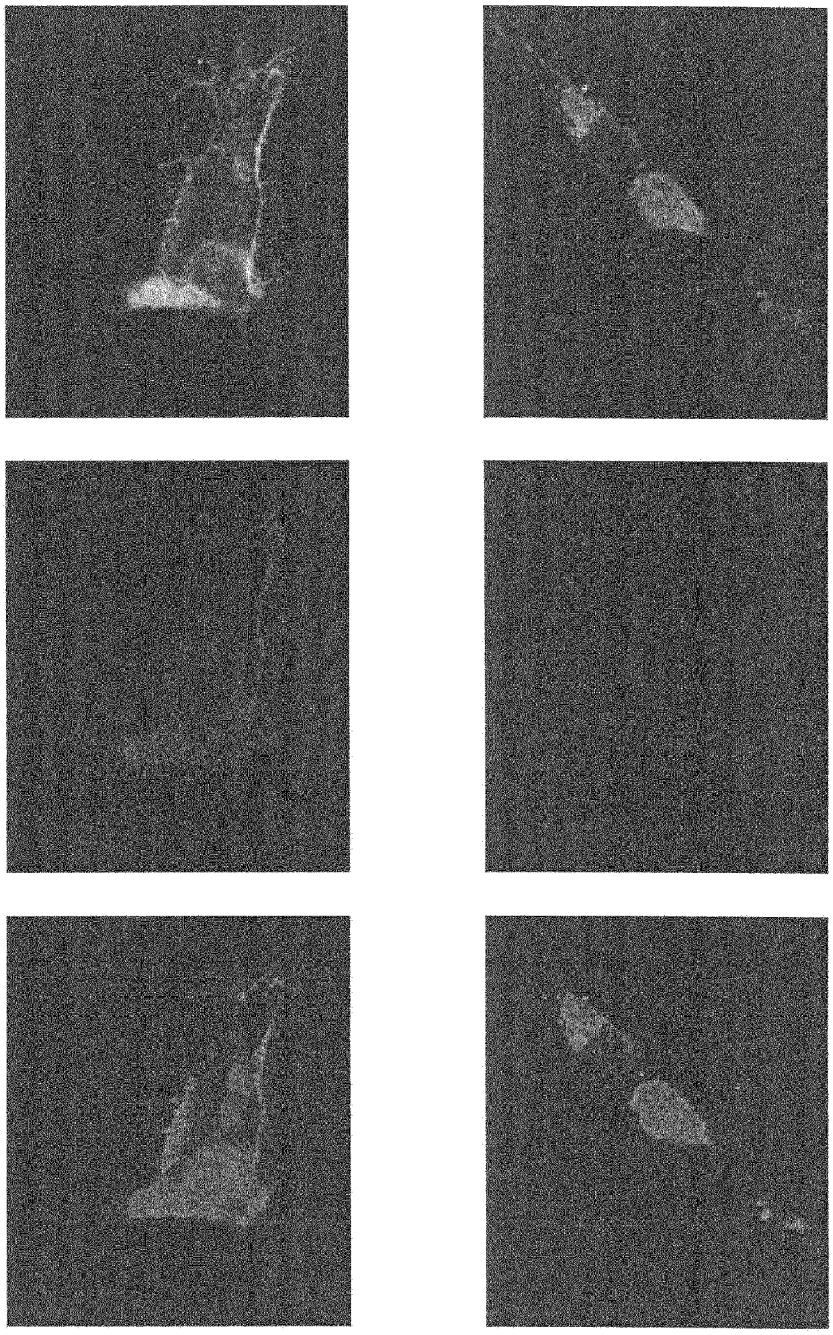
(C) (D)

Fig. 7



(A) (B)

Fig. 8



(C) (D)

Fig. 8

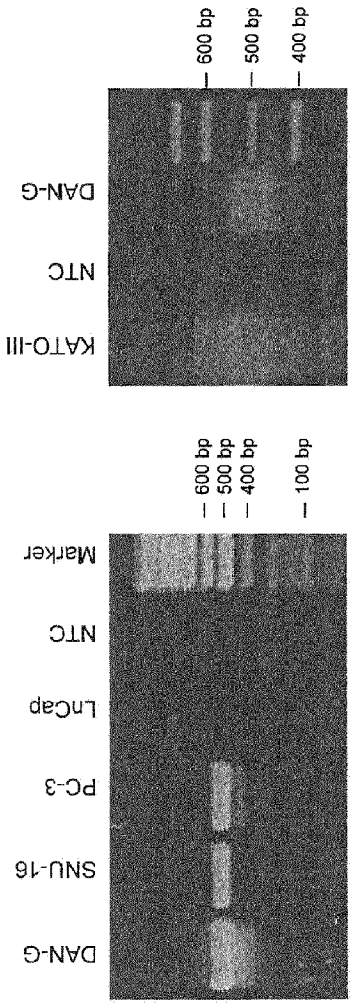

600 bp
500 bp
400 bp
DAN-G
NTC
KATO-III
600 bp
500 bp
400 bp
100 bp
Marker
NTC
LnCap
PC-3
SNU-16
DAN-G

Fig. 9

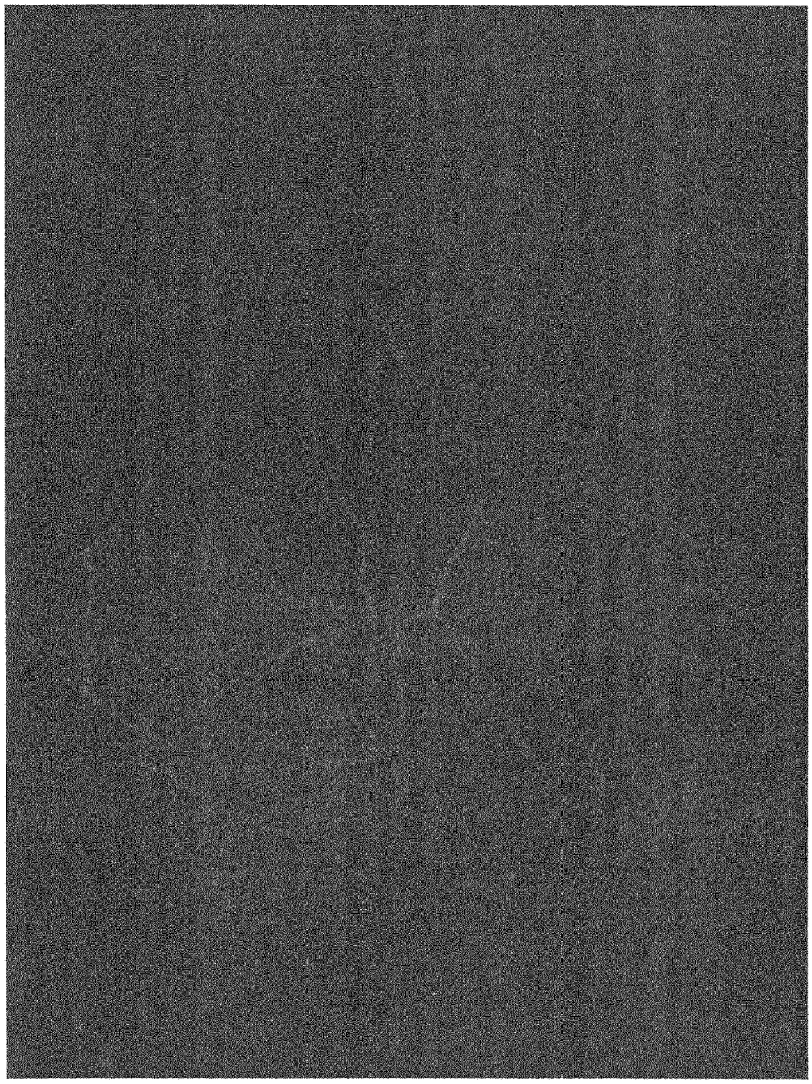


Fig. 10

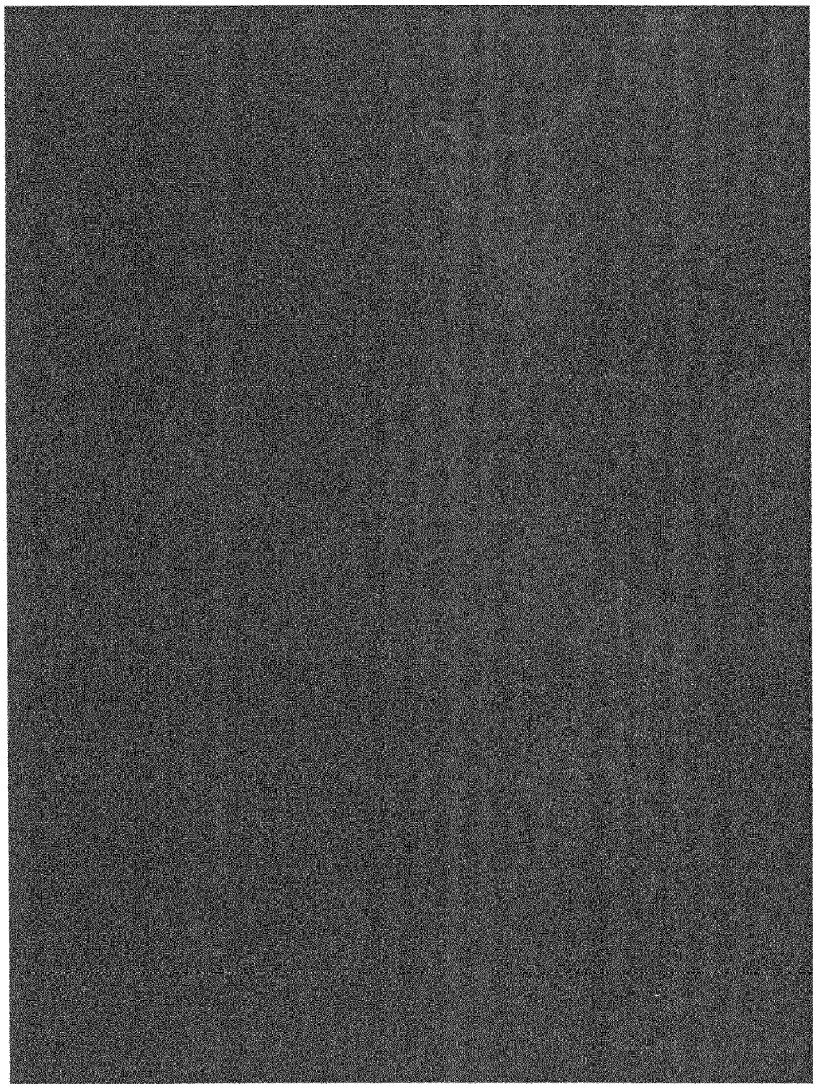


Fig. 11

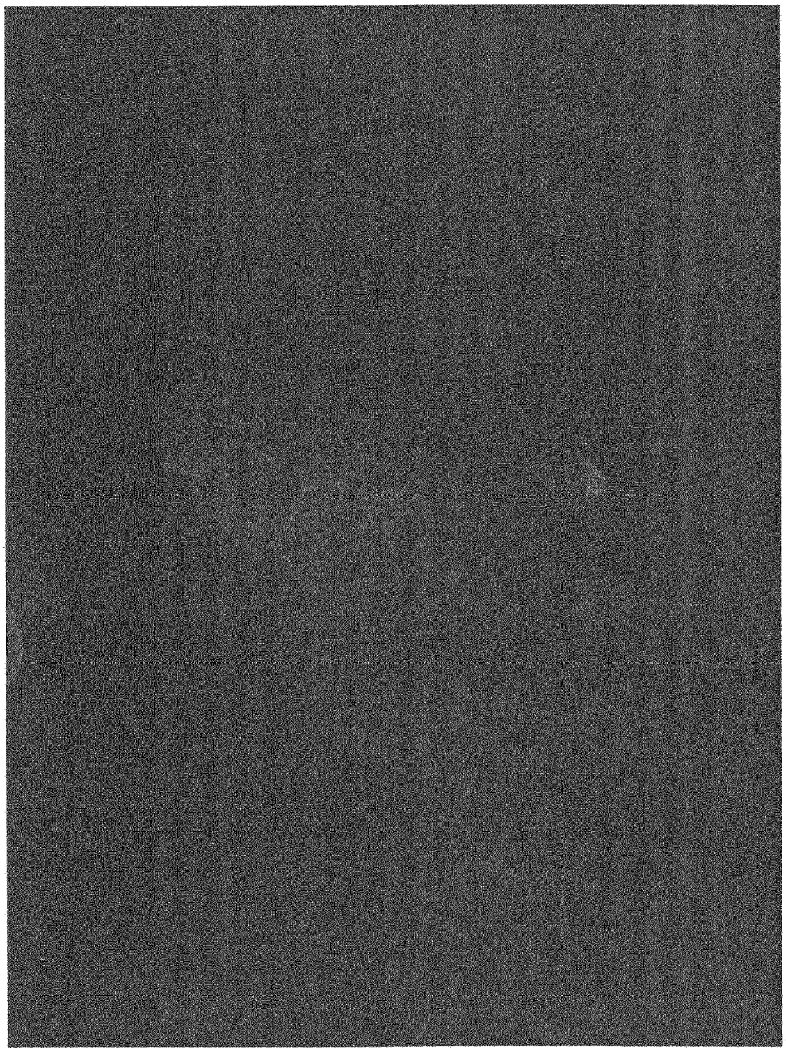
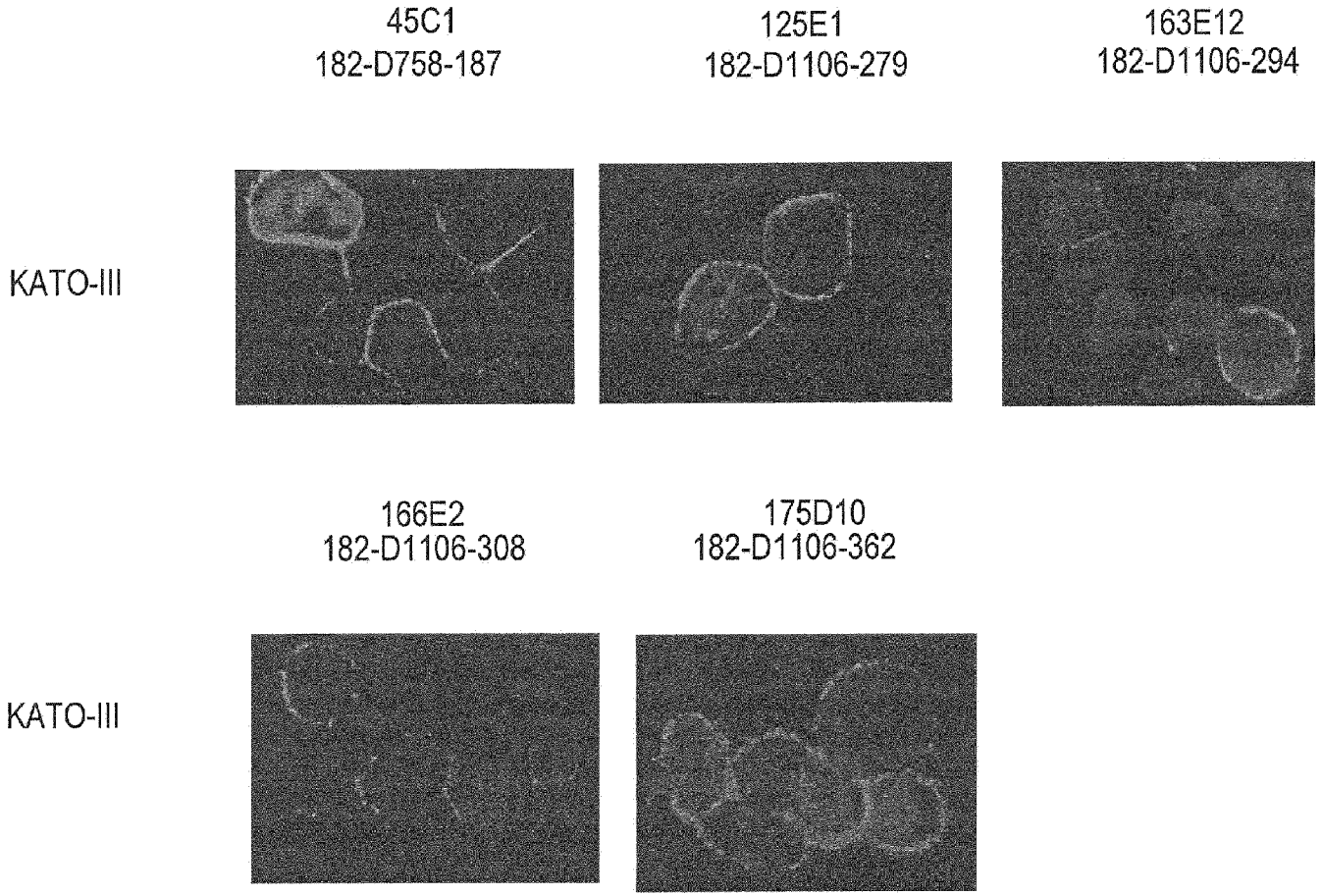


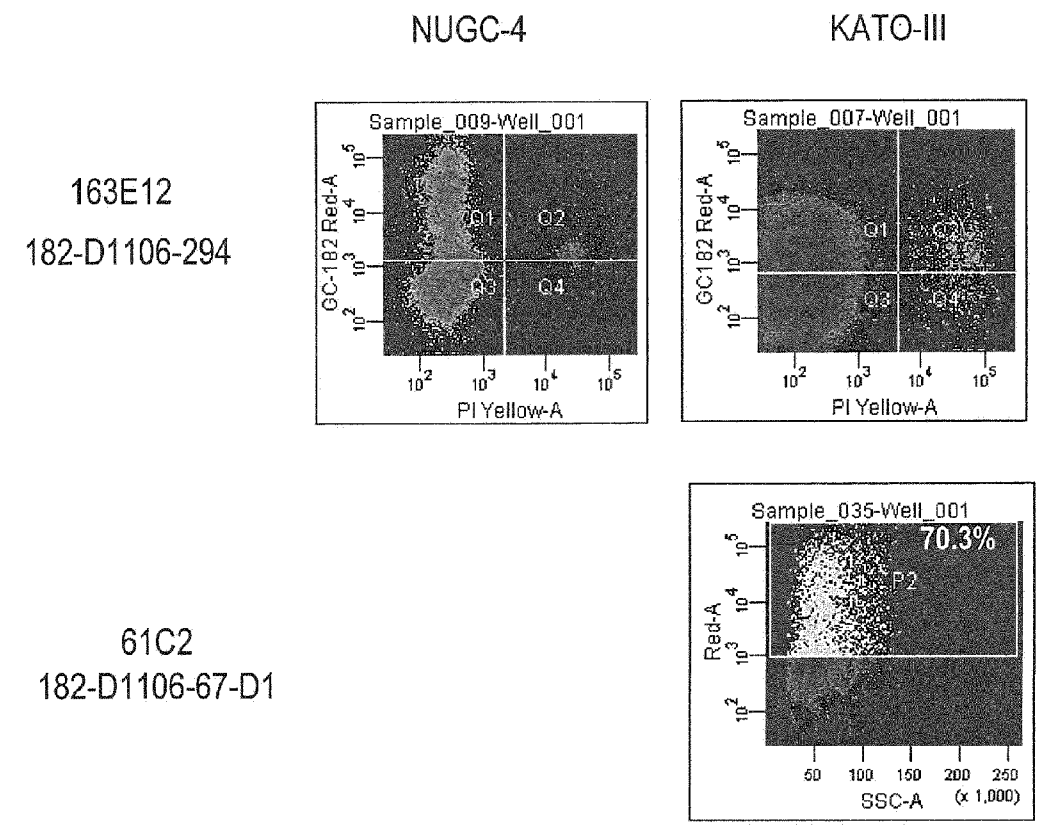
Fig. 12A

Fig. 12B



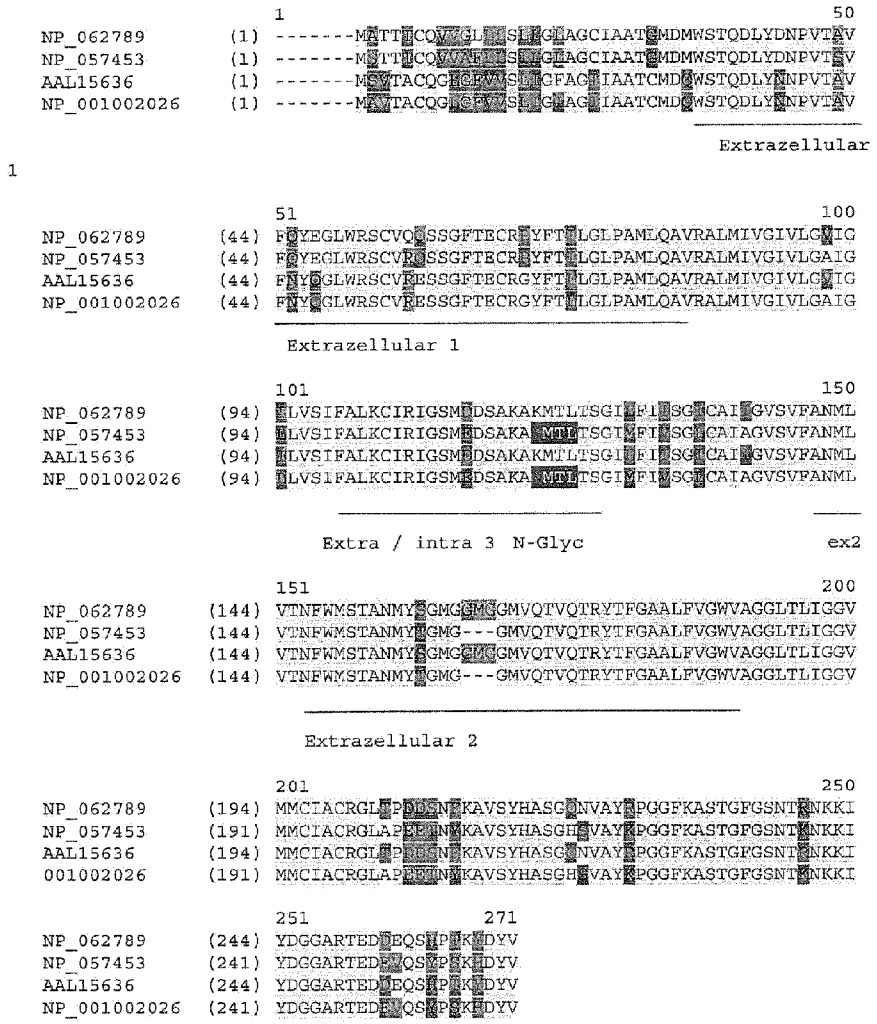
DK/EP 3401334 T3

Fig. 13



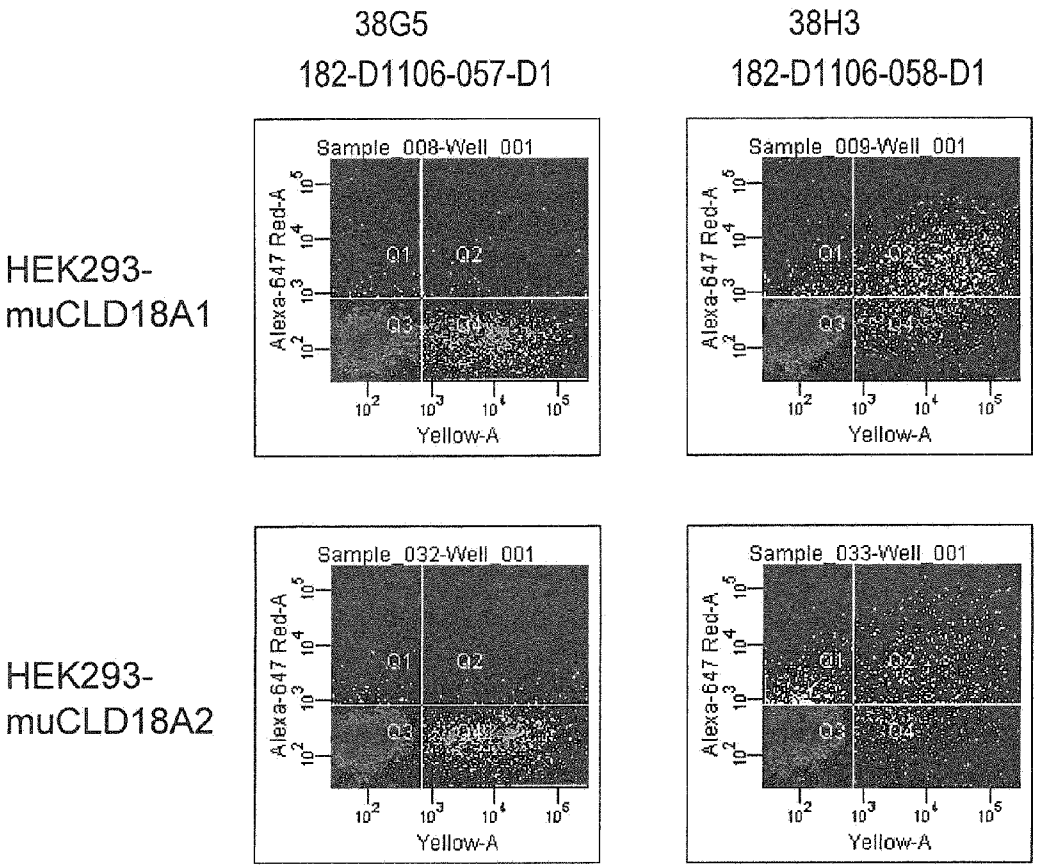
DK/EP 3401334 T3

Fig. 14



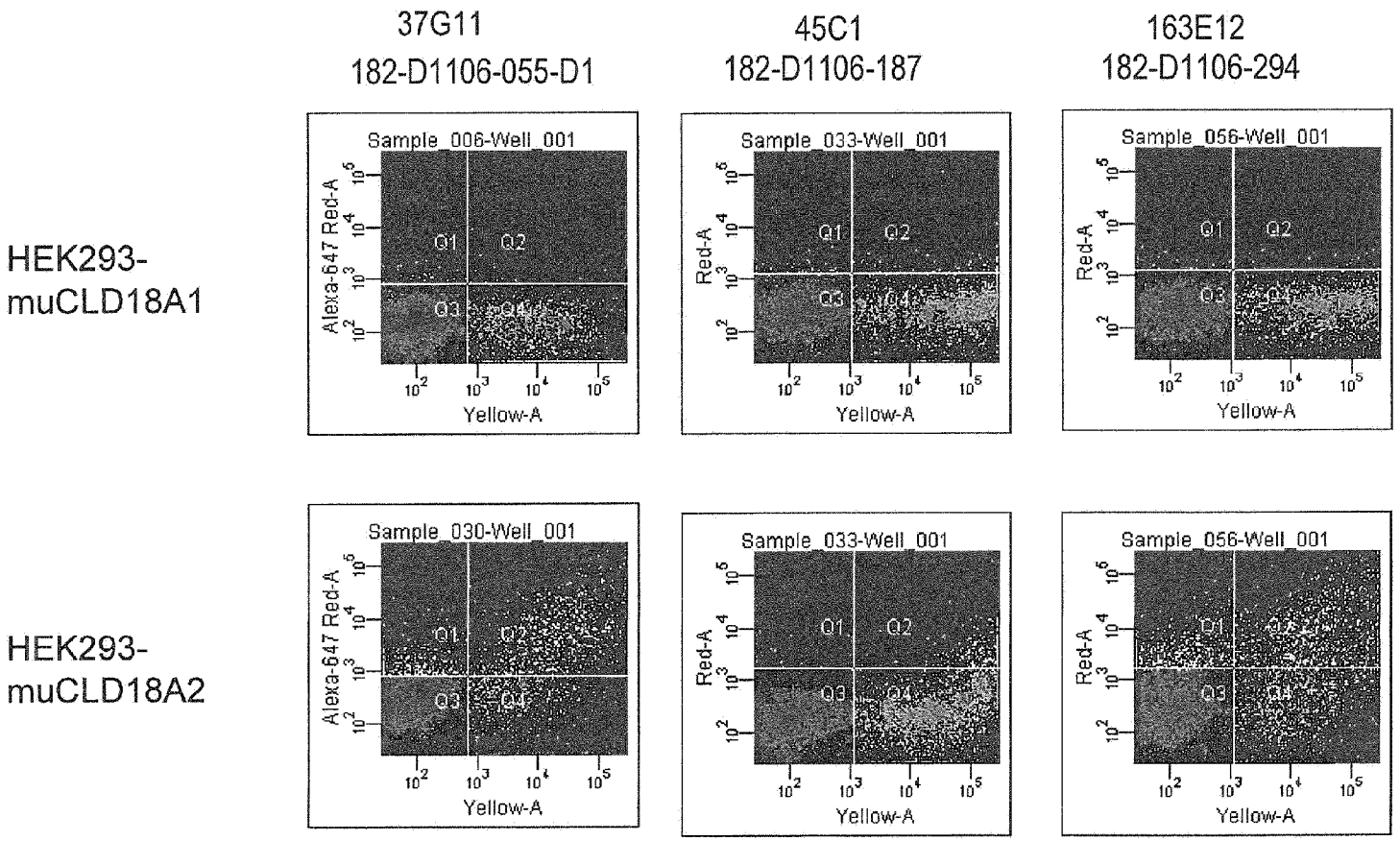
DK/EP 3401334 T3

Fig. 15A



DK/EP 3401334 T3

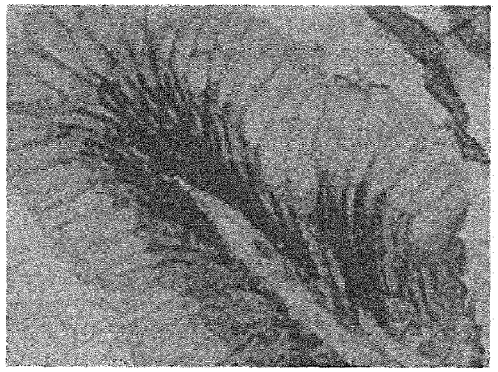
Fig. 15B



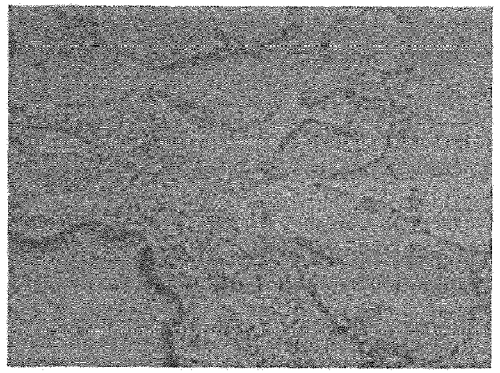
DK/EP 3401334 T3

Fig. 16

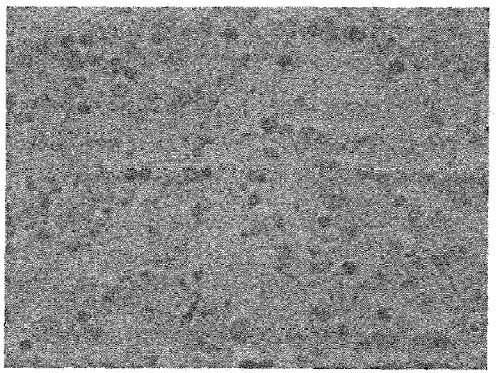
(A)



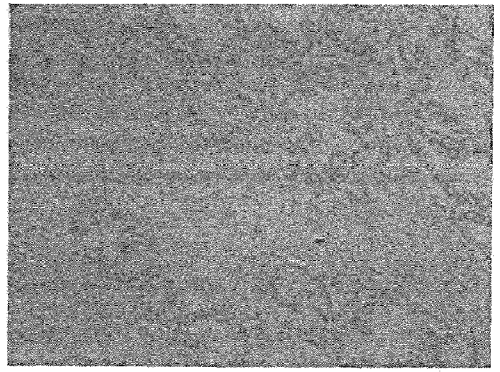
Stomach



Lung



Bone marrow



Prostate

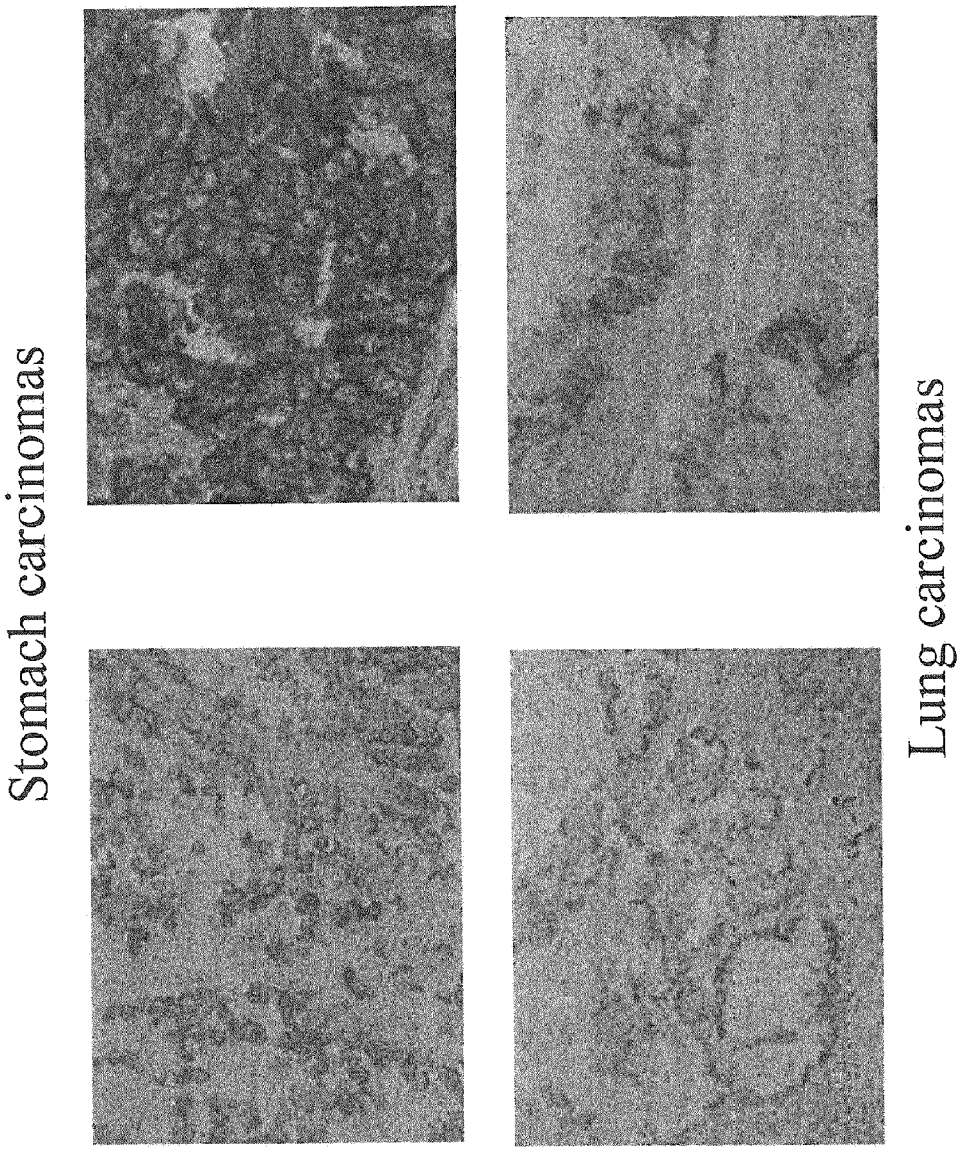
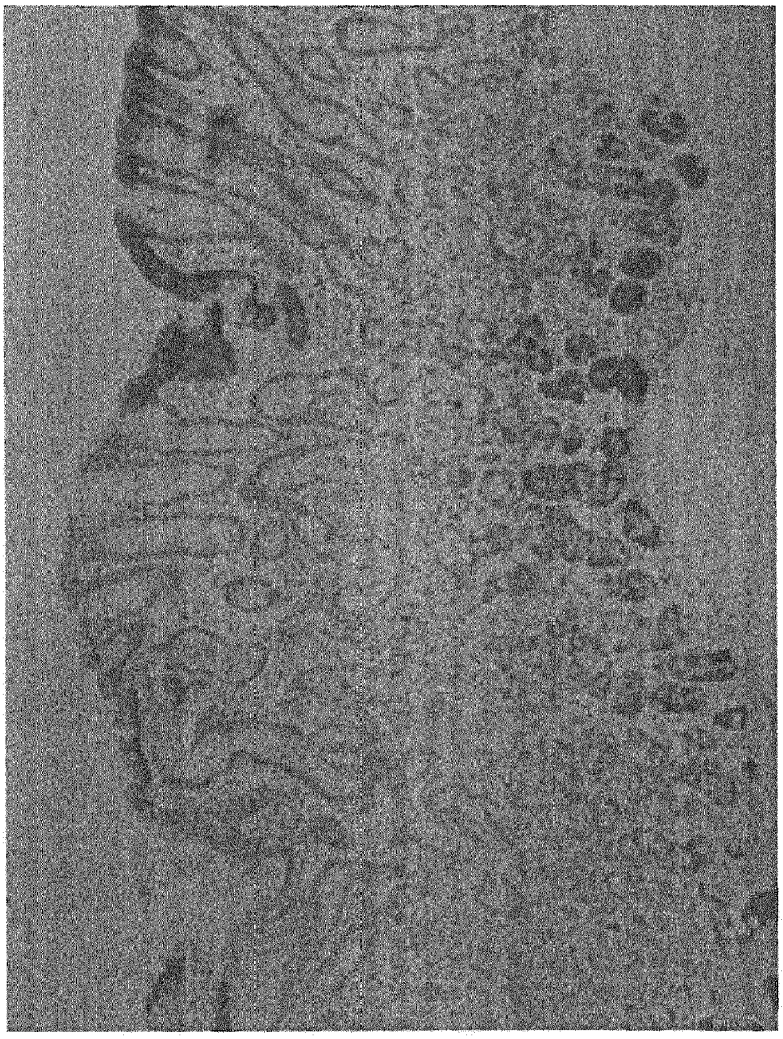


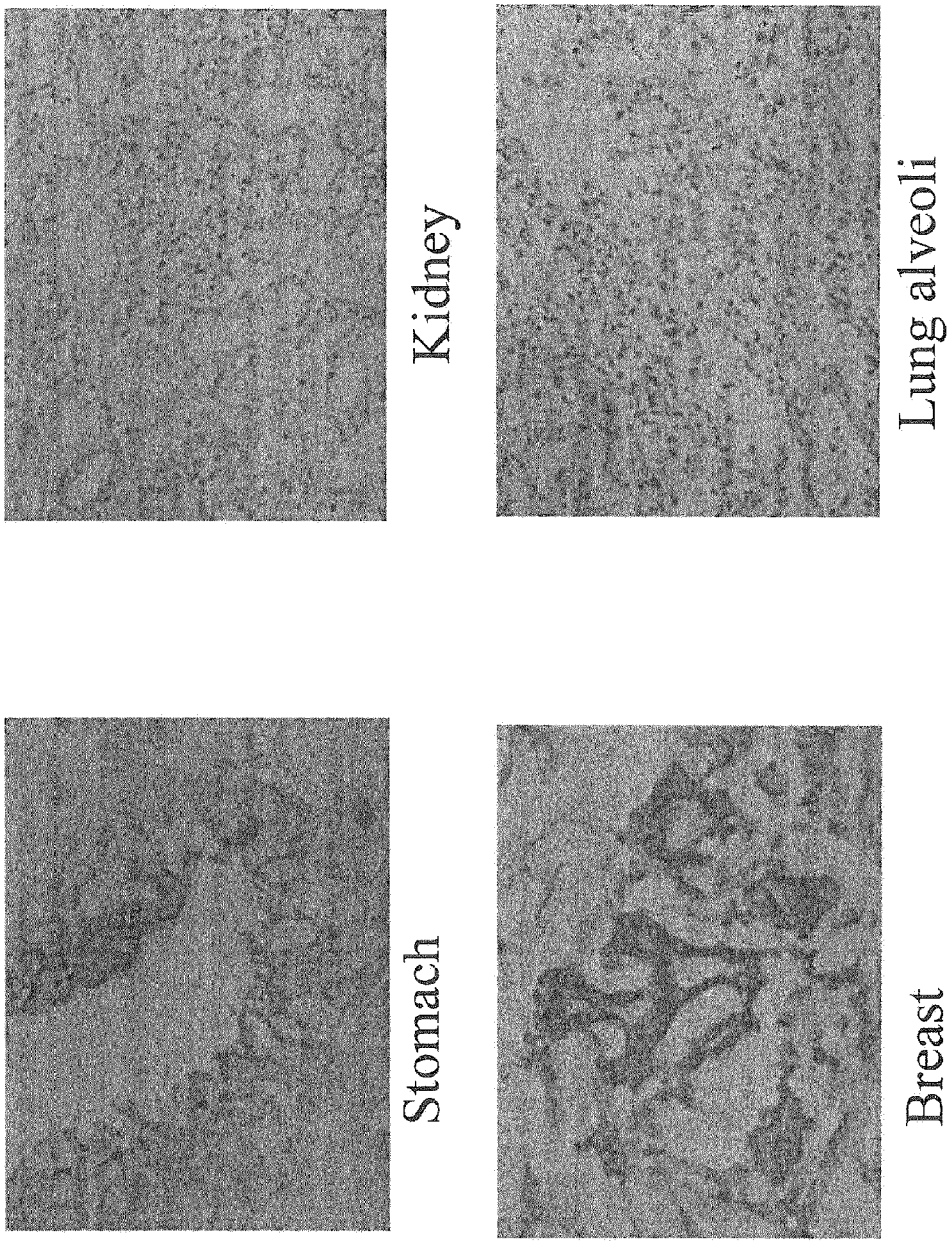
Fig. 16



(C)

Fig. 16

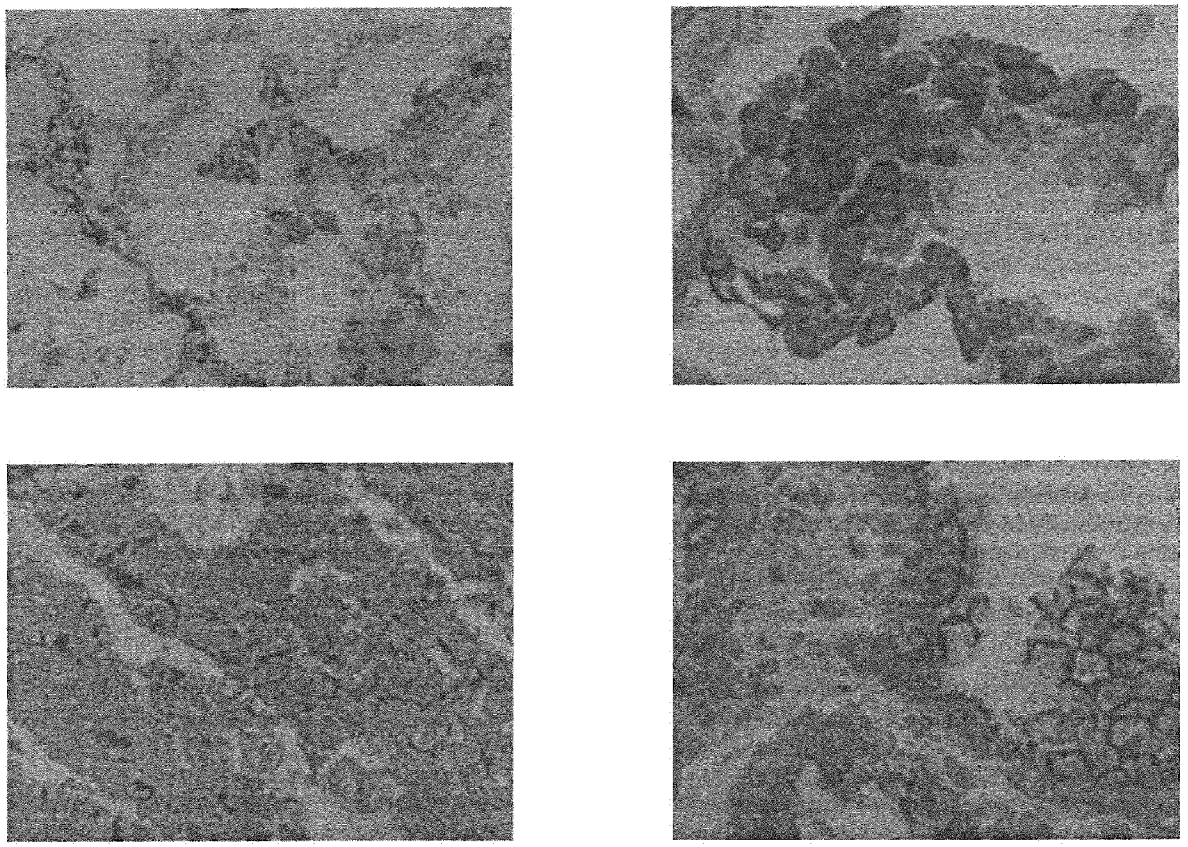
Fig. 17



(A)

Fig. 17

(B)



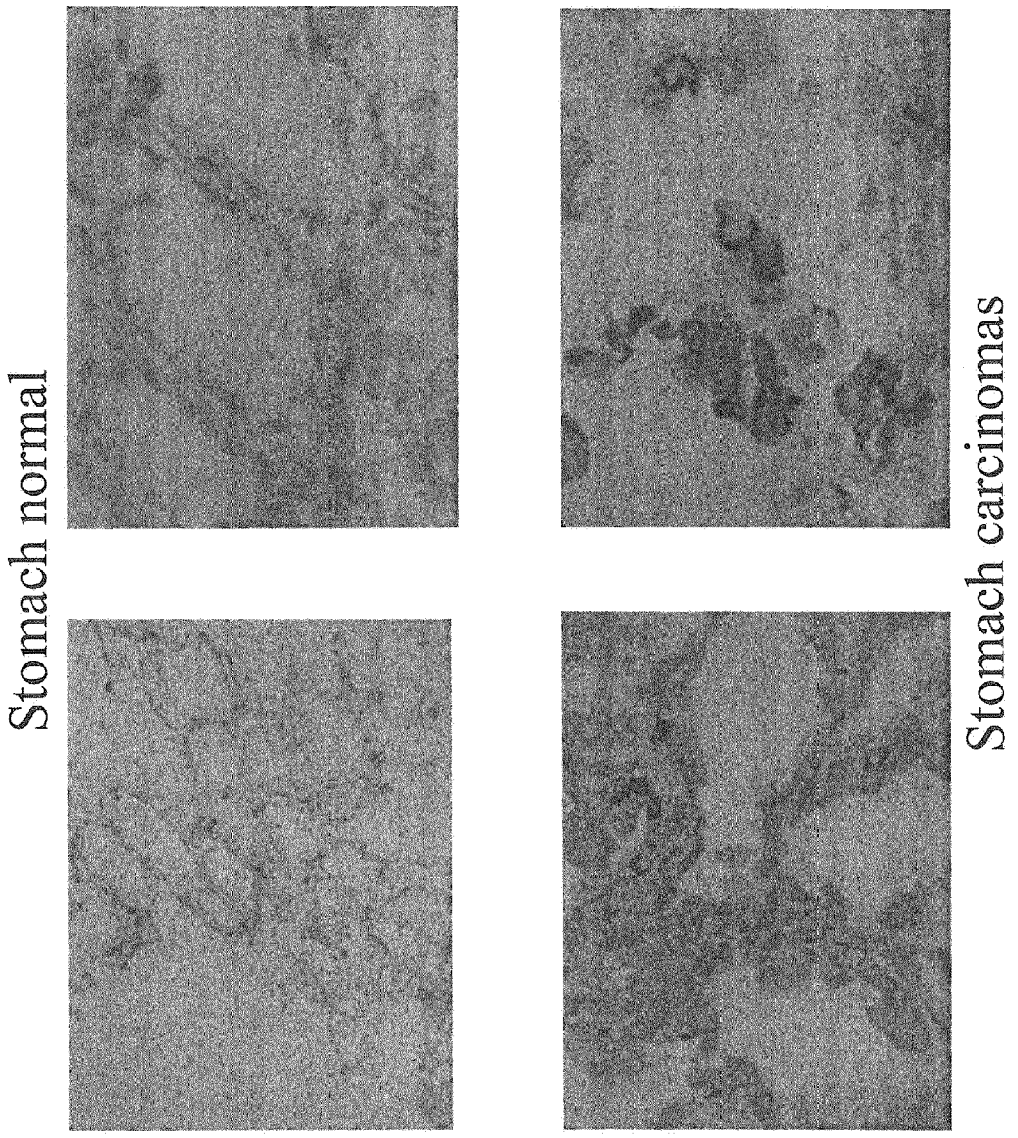


Fig. 18A

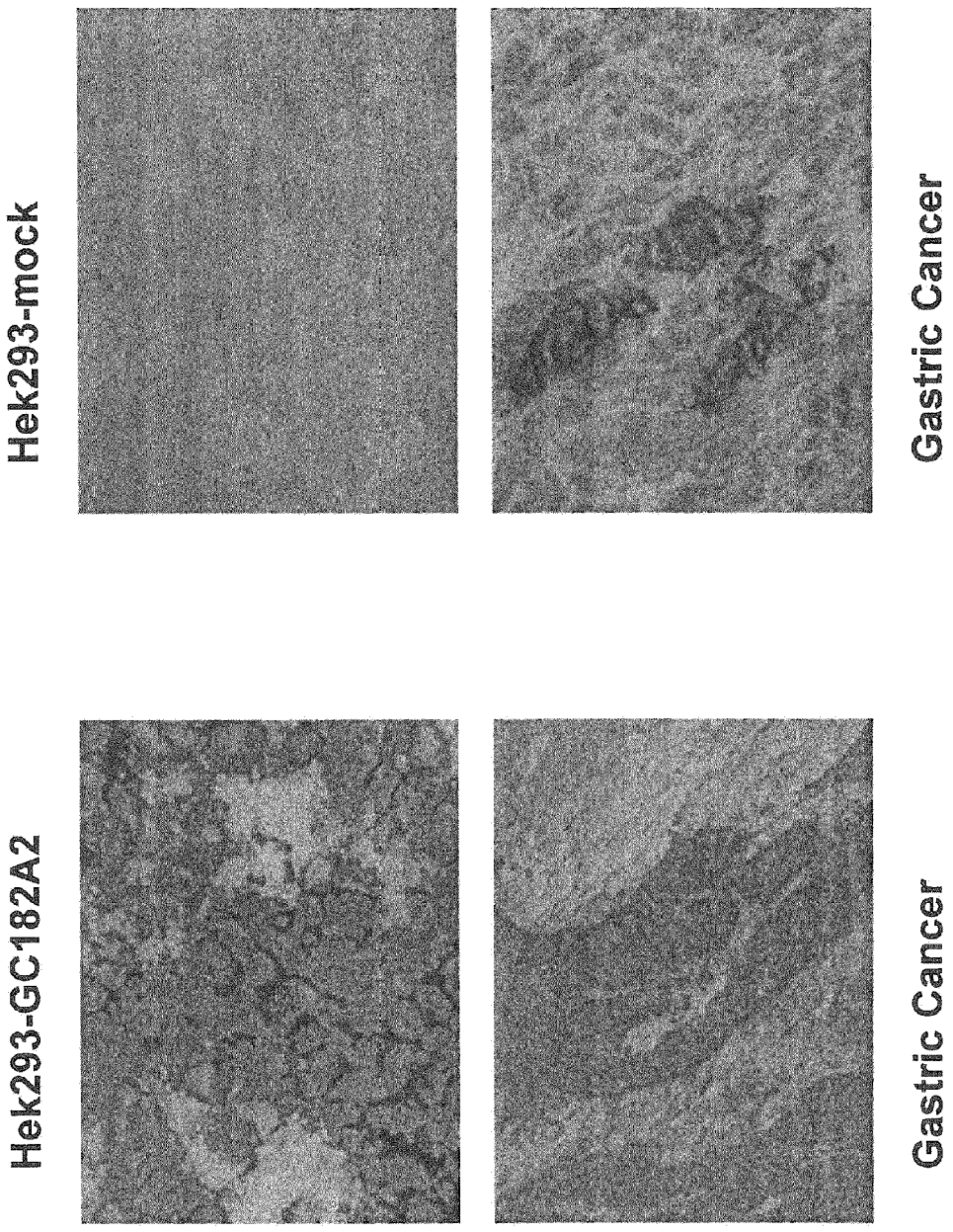


Fig. 18B

Fig. 18C

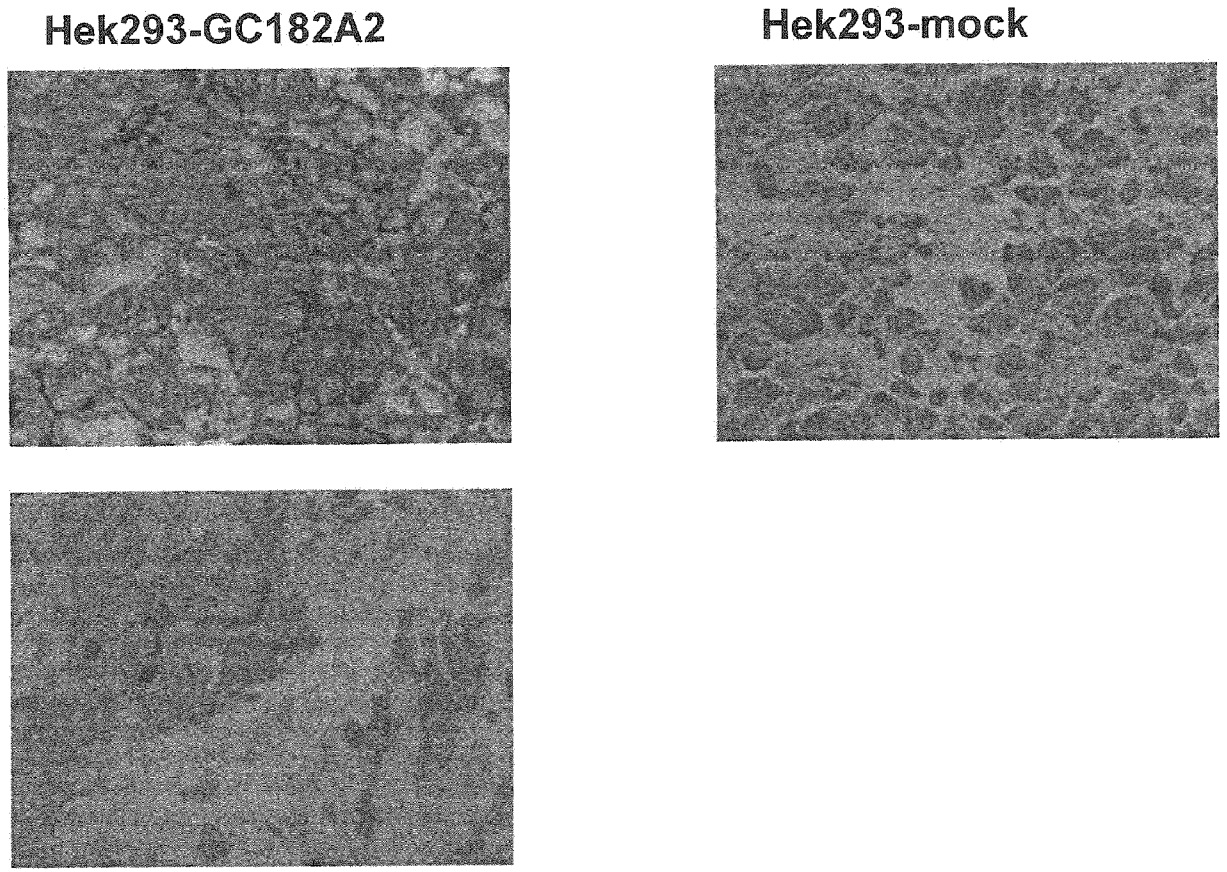


Fig. 18D

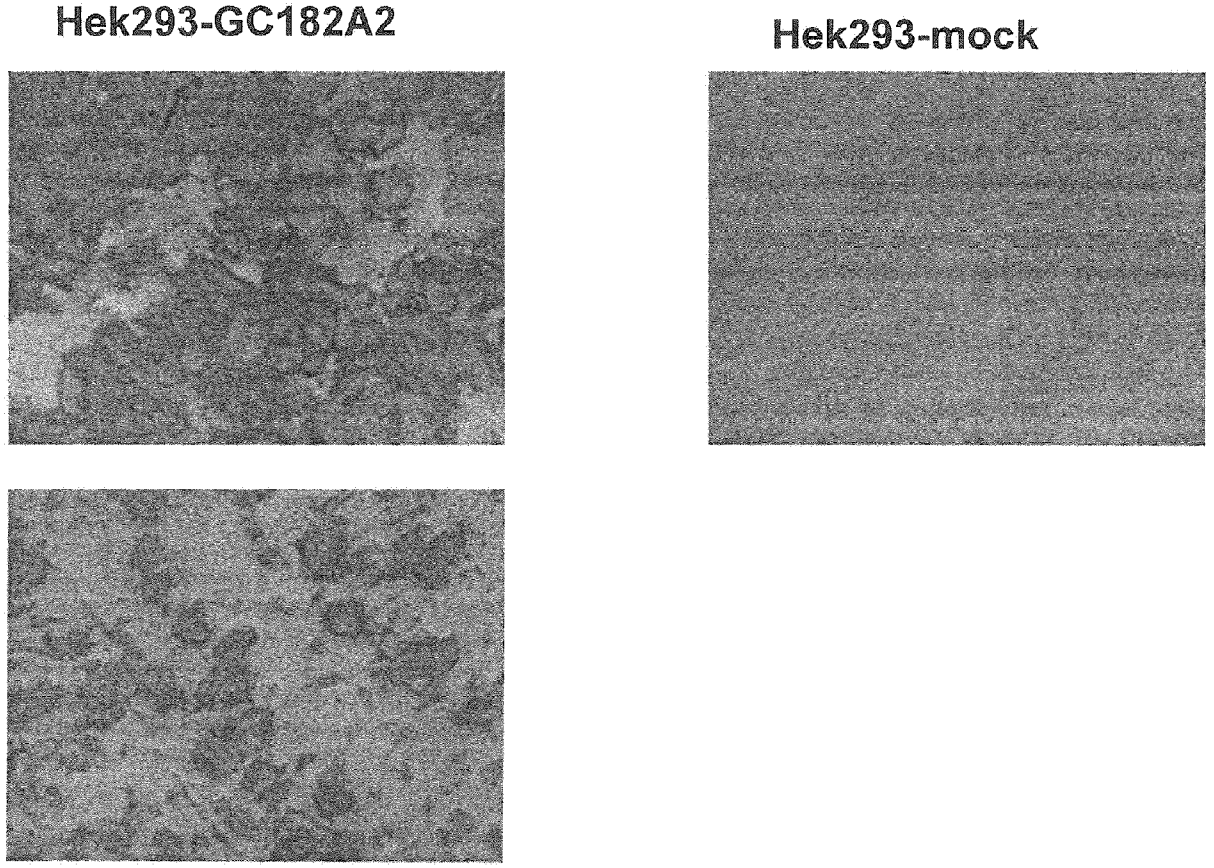
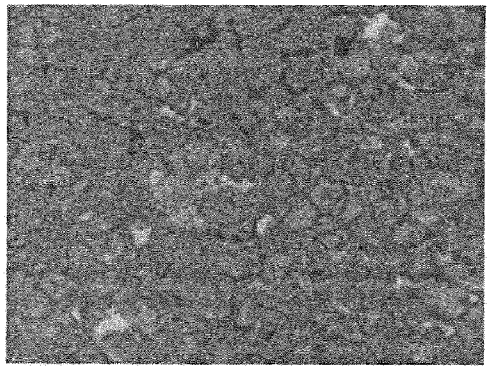
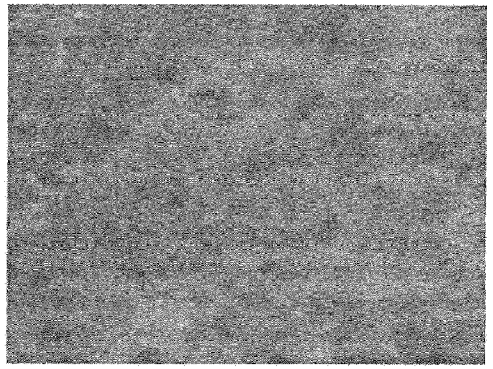


Fig. 18E

Hek293-GC182A2



Hek293-mock



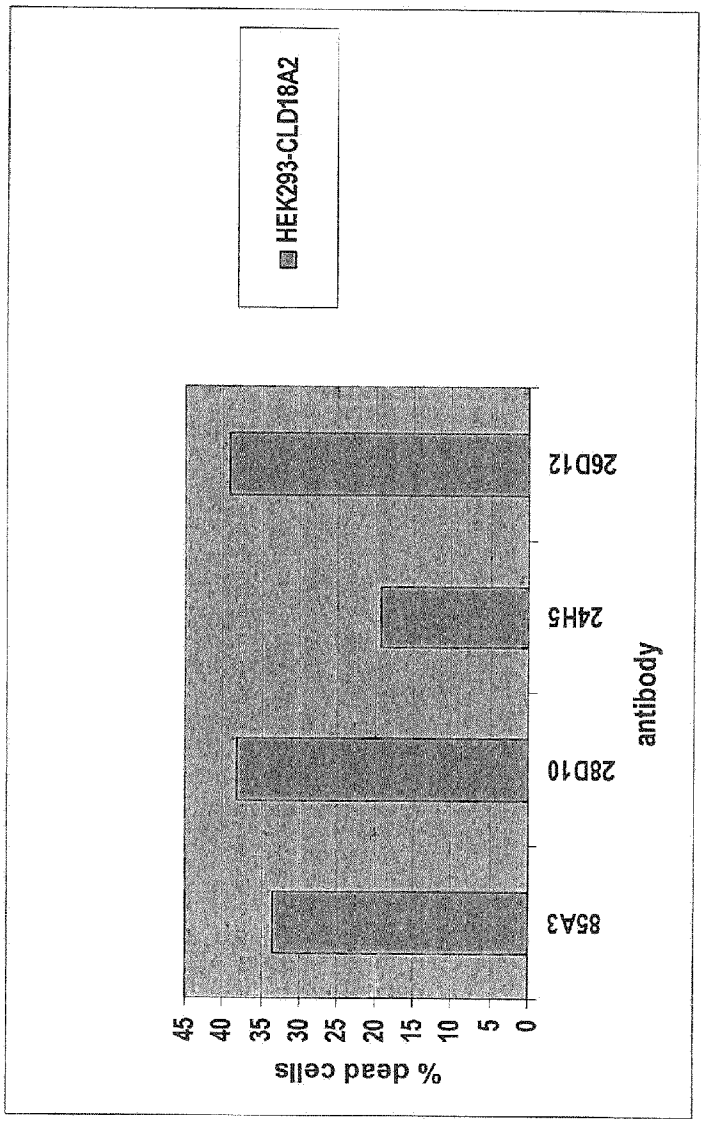

HEK293-CLD18A2
% dead cells
0
5
10
15
20
25
30
35
40
45
85A3
28D10
24H5
26D12
antibody

Fig. 19

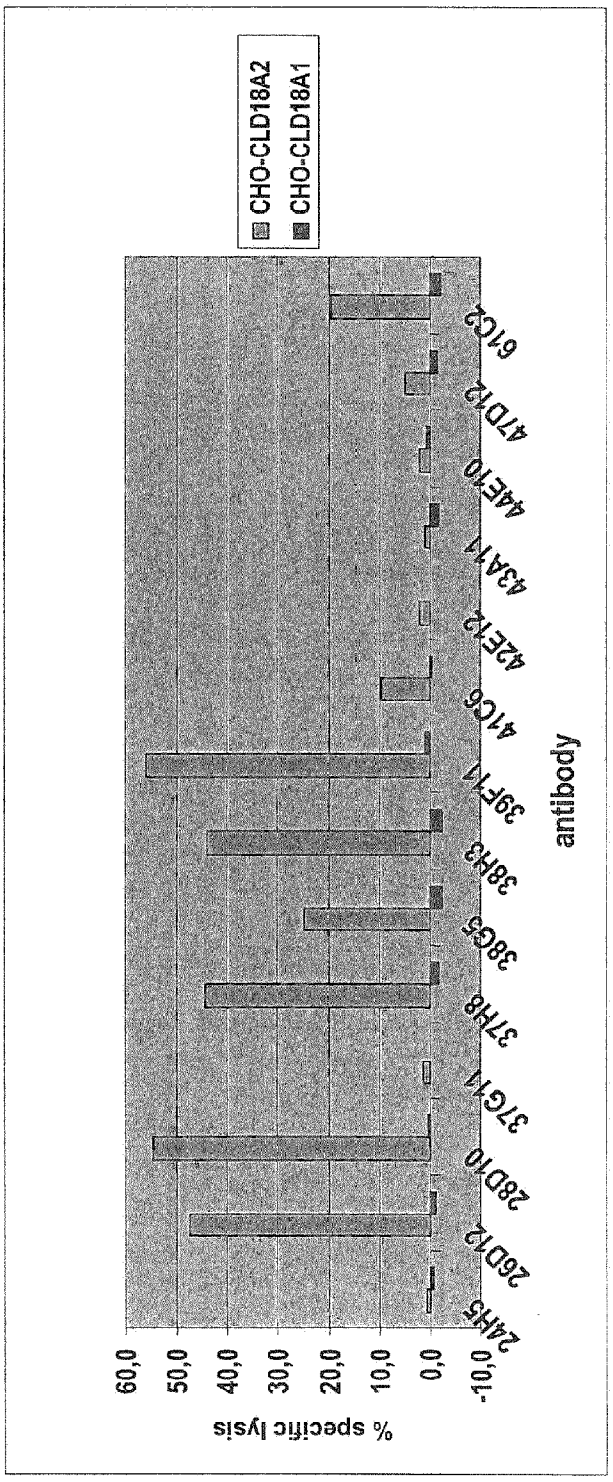

CHO-CLD18A2
CHO-CLD18A1
% specific lysis
60,0
50,0
40,0
30,0
20,0
10,0
0,0
-10,0
antibody
24H5
26D12
28D10
37G1
37H8
38G5
38H3
39F1
41C6
42E12
43A1
44E10
47D12
61C2

Fig. 20

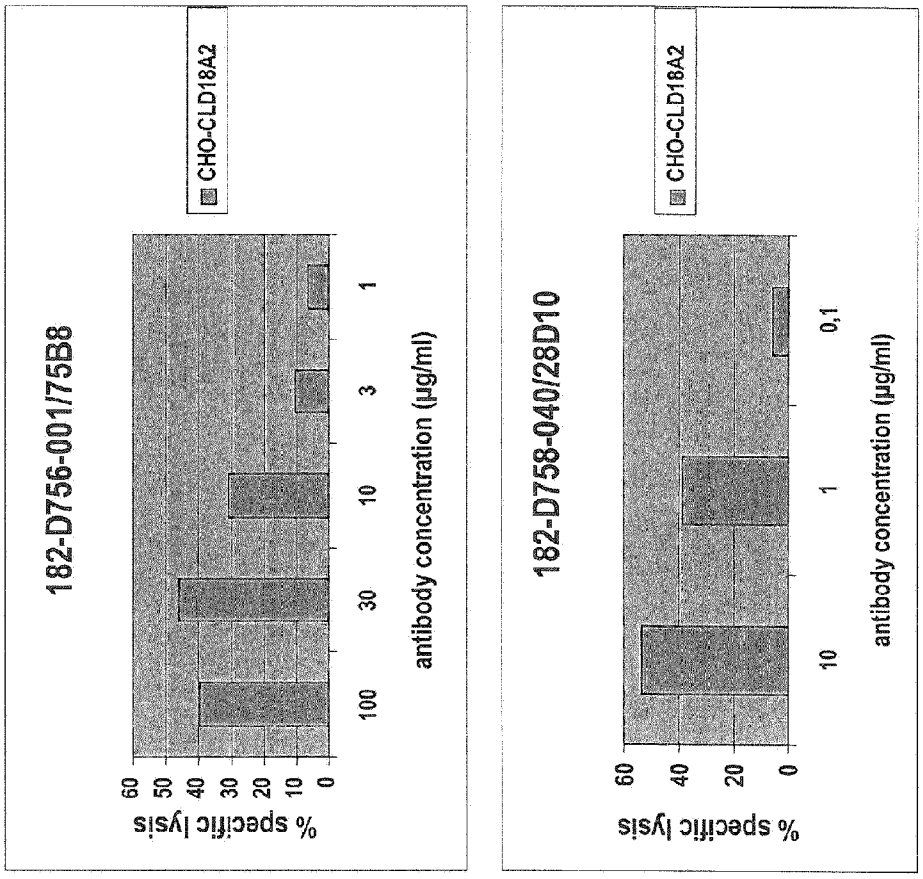
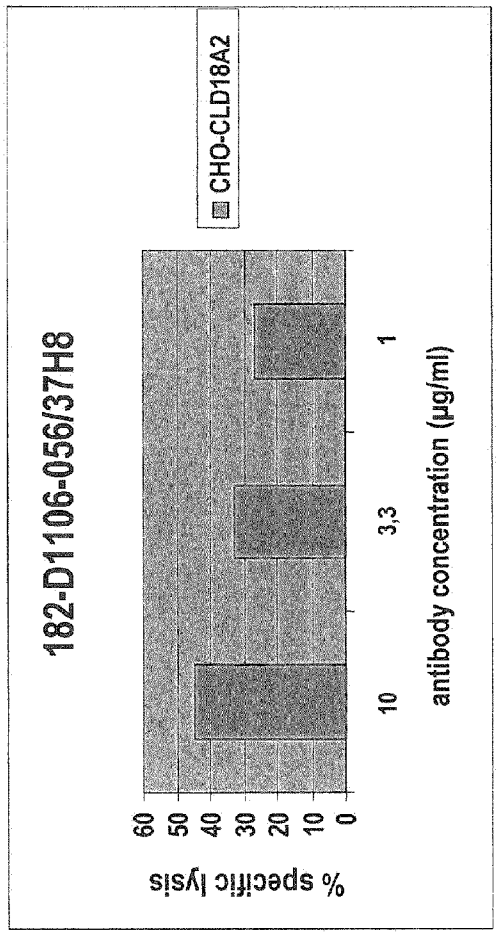

(A)
182-D756-001/75B8
CHO-CLD18A2
% specific lysis
0
10
20
30
40
50
60
100
30
10
3
1
antibody concentration (µg/ml)
(B)
182-D758-040/28D10
CHO-CLD18A2
% specific lysis
0
20
40
60
10
1
0,1
antibody concentration (µg/ml)

Fig. 21


182-D1106-056/37H8
CHO-CLD18A2
% specific lysis
0
10
20
30
40
50
60
10
3,3
1
antibody concentration (µg/ml)

(C)

Fig. 21

Fig. 22

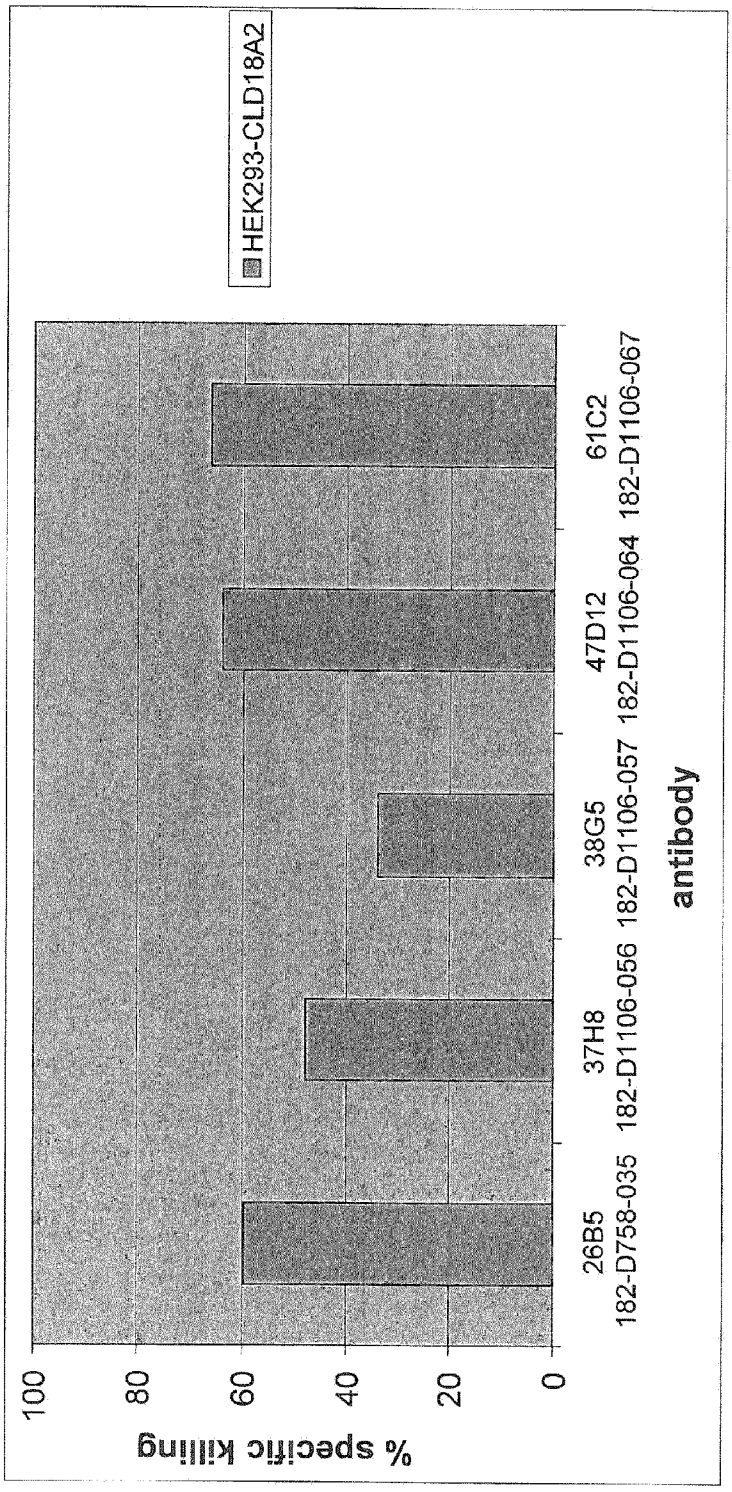
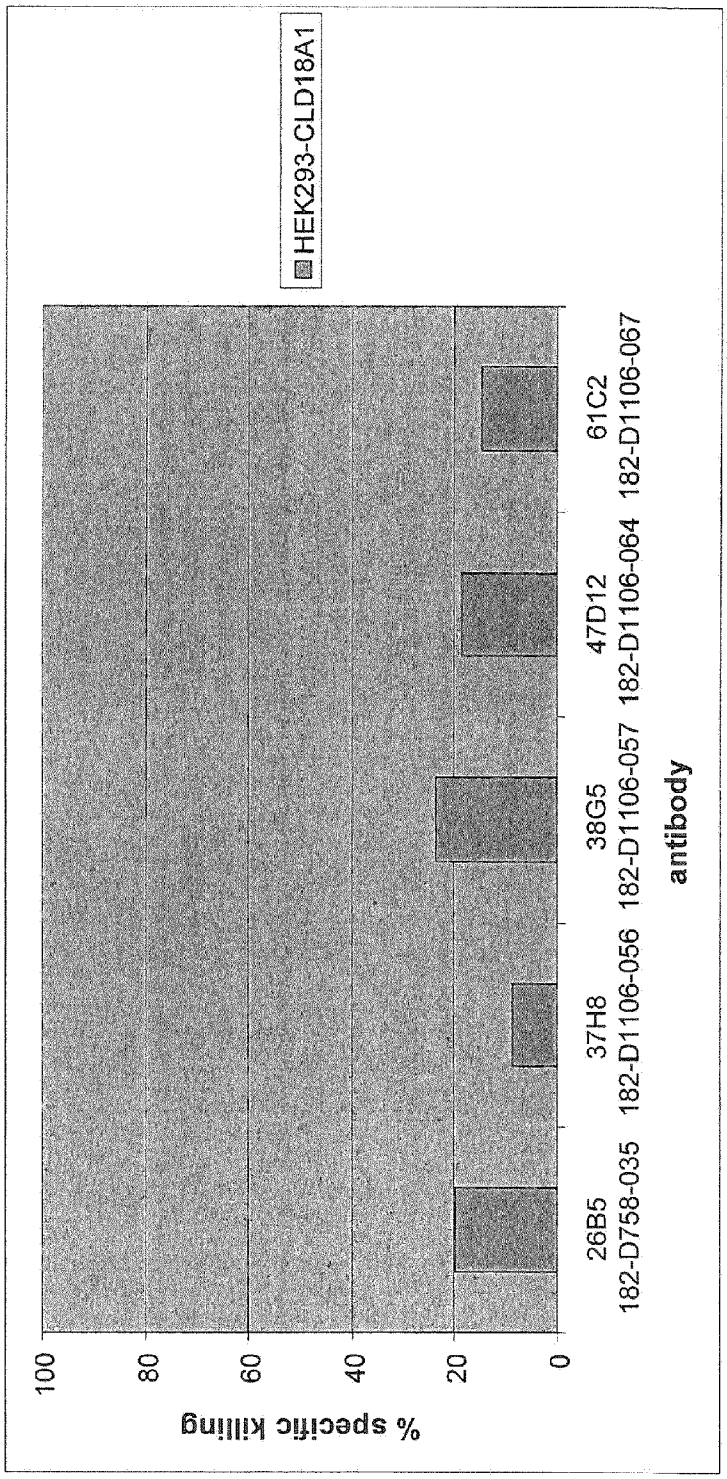

HEK293-CLD18A2
% specific killing
100
80
60
40
20
0
26B5
182-D758-035
37H8
182-D1106-056
38G5
182-D1106-057
47D12
182-D1106-064
61C2
182-D1106-067
antibody

Fig. 23


HEK293-CLD18A1
% specific killing
100
80
60
40
20
0
26B5
182-D758-035
37H8
182-D1106-056
38G5
182-D1106-057
47D12
182-D1106-064
61C2
182-D1106-067
antibody

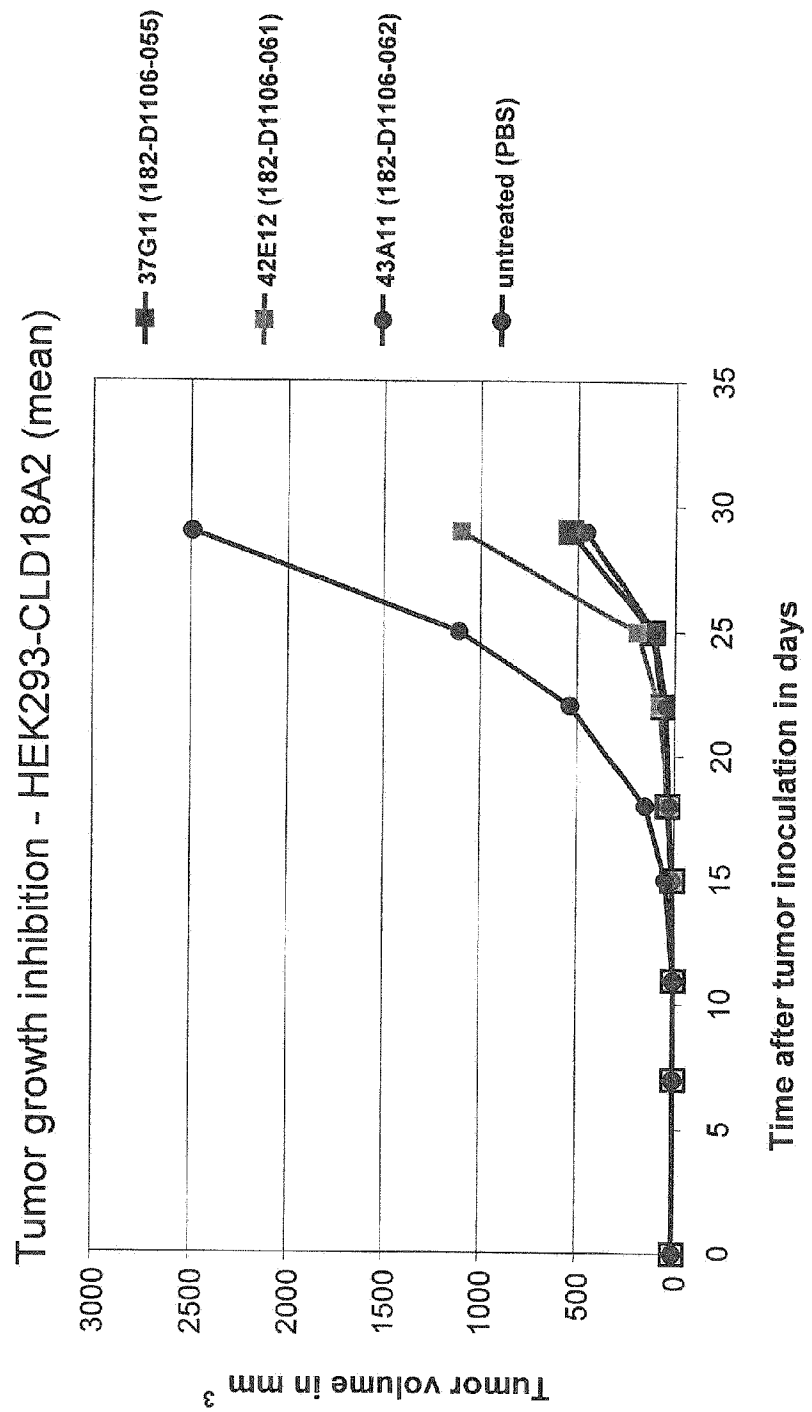

Tumor growth inhibition - HEK293-CLD18A2 (mean)
37G11 (182-D1106-055)
42E12 (182-D1106-061)
43A11 (182-D1106-062)
untreated (PBS)
Tumor volume in mm 3
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
Time after tumor inoculation in days

Fig. 24

Fig. 25A

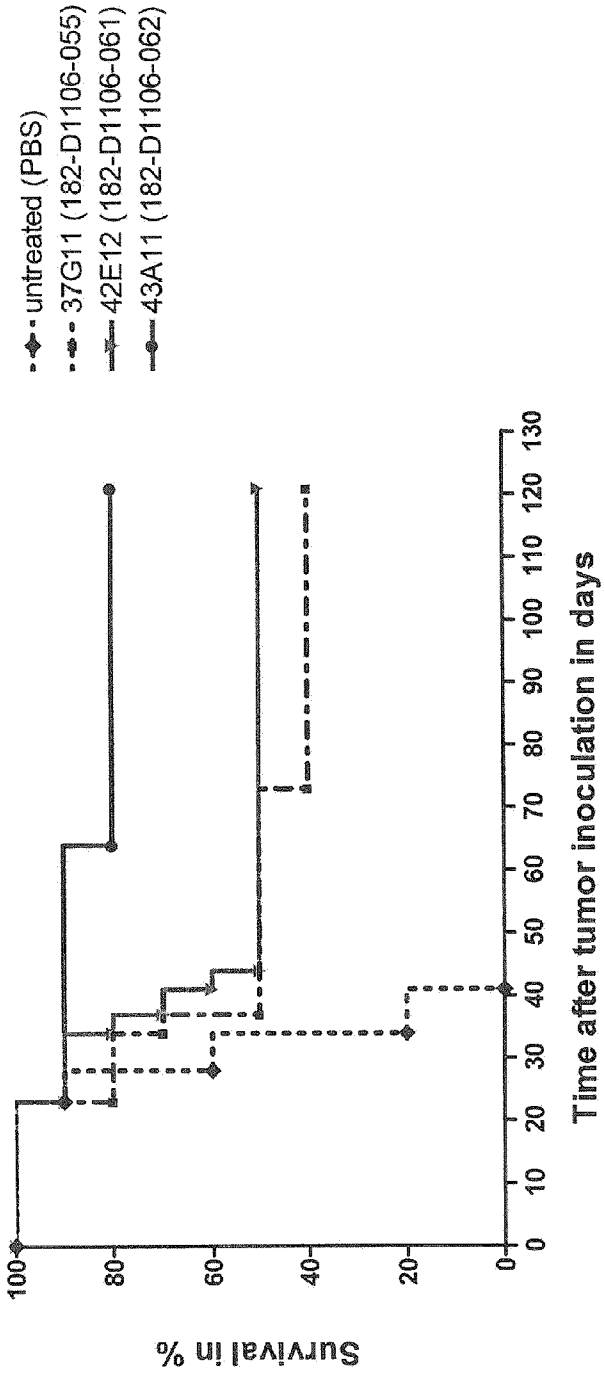
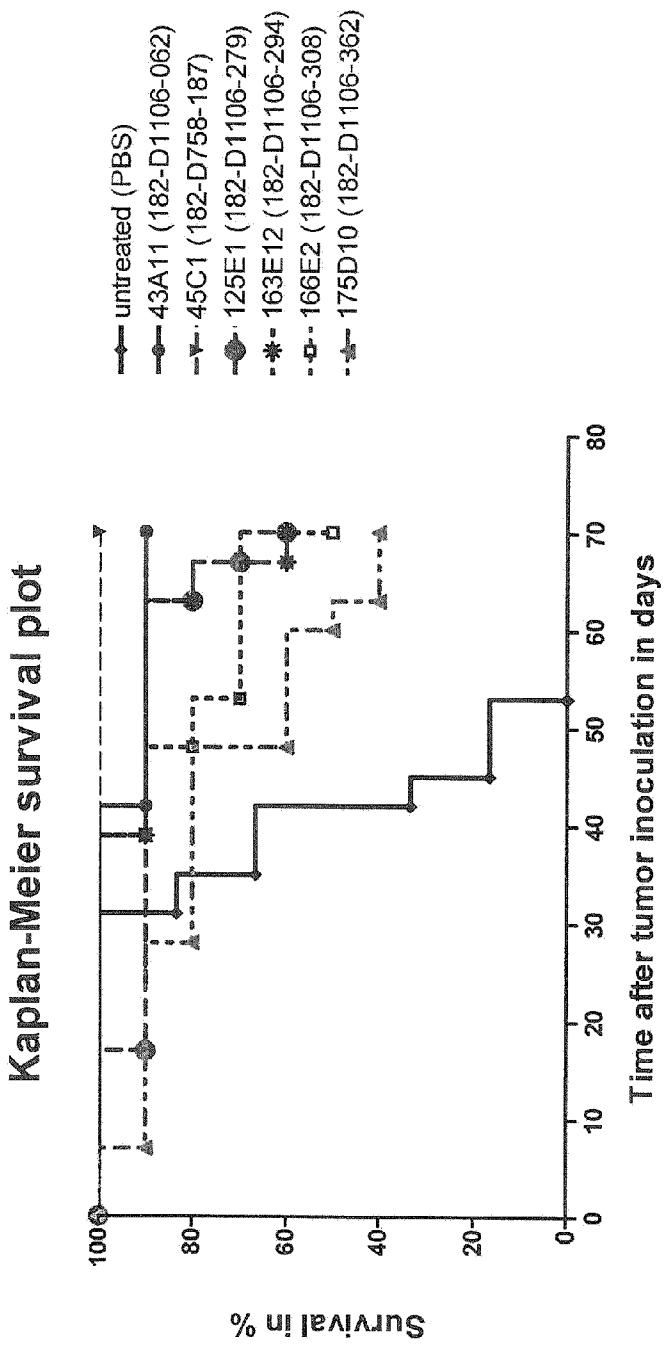

Kaplan-Meier survival plot
untreated (PBS)
37G11 (182-D1106-055)
42E12 (182-D1106-061)
43A11 (182-D1106-062)
Survival in %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Time after tumor inoculation in days

Fig. 25B


Kaplan-Meier survival plot
untreated (PBS)
43A11 (182-D1106-062)
45C1 (182-D758-187)
125E1 (182-D1106-279)
163E12 (182-D1106-294)
166E2 (182-D1106-308)
175D10 (182-D1106-362)
Survival in %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Time after tumor inoculation in days

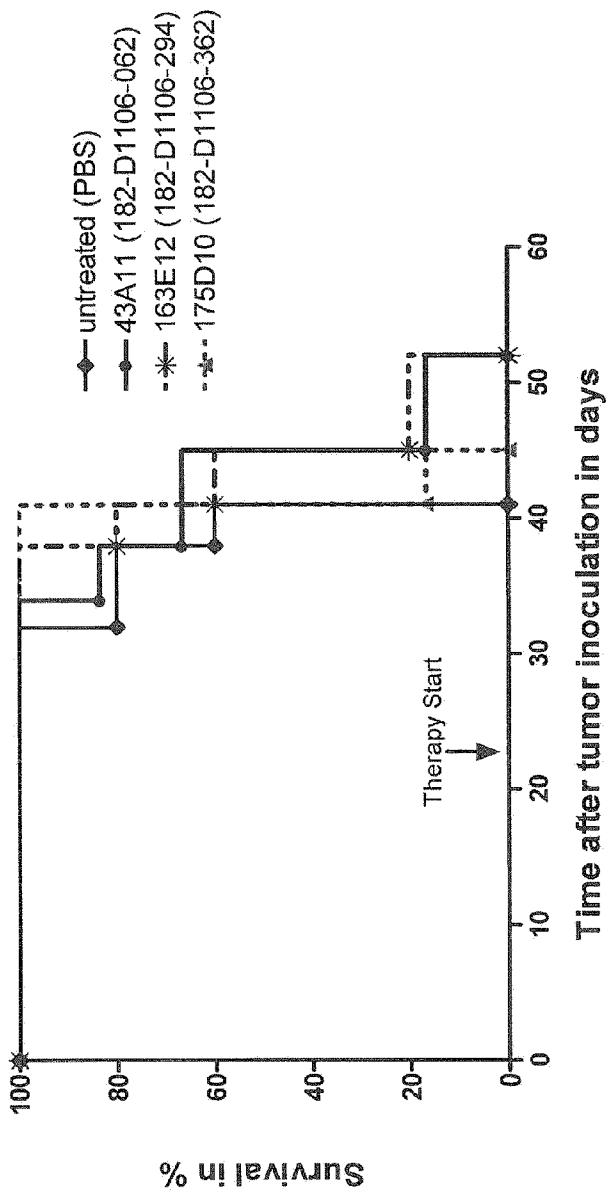

Kaplan-Meier survival plot
untreated (PBS)
43A11 (182-D1106-062)
163E12 (182-D1106-294)
175D10 (182-D1106-362)
Therapy Start
Survival in %
Time after tumor inoculation in days
0
20
40
60
80
100
0
10
20
30
40
50
60

Fig. 26

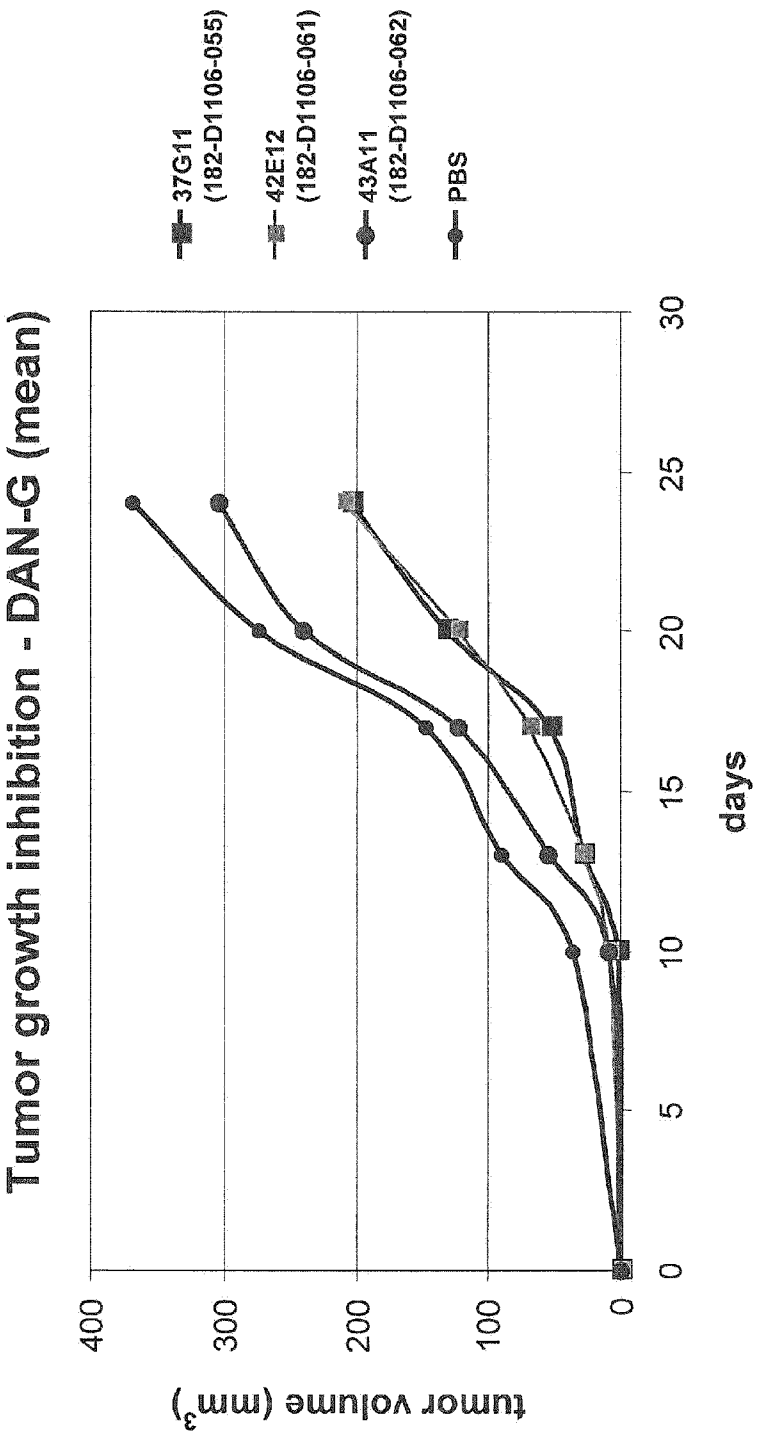

Tumor growth inhibition - DAN-G (mean)
37G11 (182-D1106-055)
42E12 (182-D1106-061)
43A11 (182-D1106-062)
PBS
tumor volume (mm³)
400
300
200
100
0
0
5
10
15
20
25
30
days

Fig. 27A

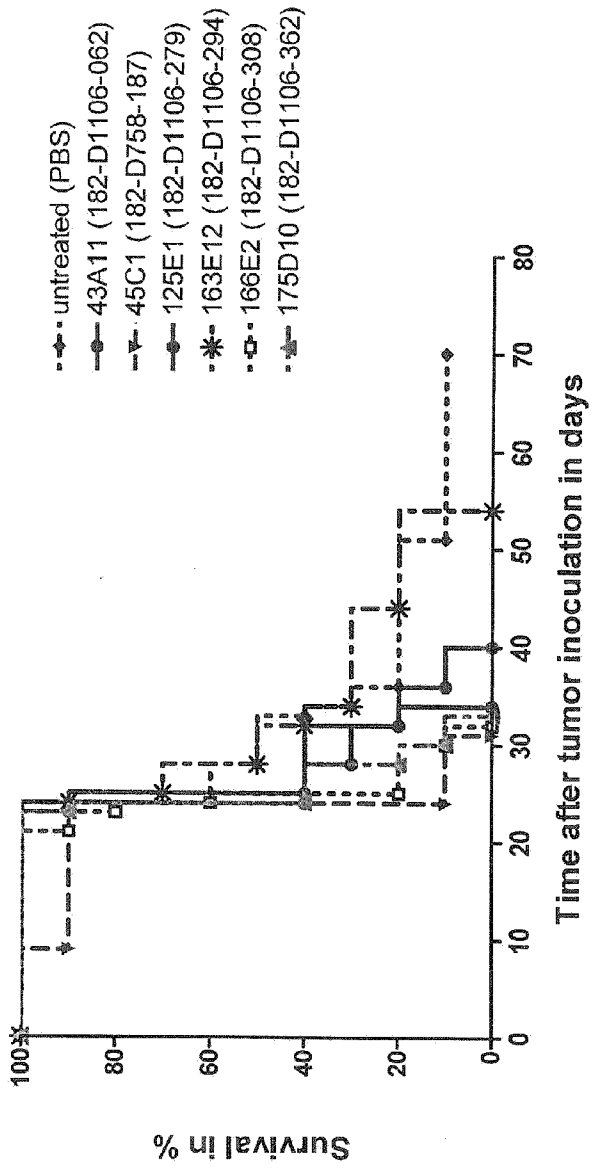

Kaplan-Meier survival plot
untreated (PBS)
43A11 (182-D1106-062)
45C1 (182-D758-187)
125E1 (182-D1106-279)
163E12 (182-D1106-294)
166E2 (182-D1106-308)
175D10 (182-D1106-362)
Survival in %
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Time after tumor inoculation in days

Fig. 27B

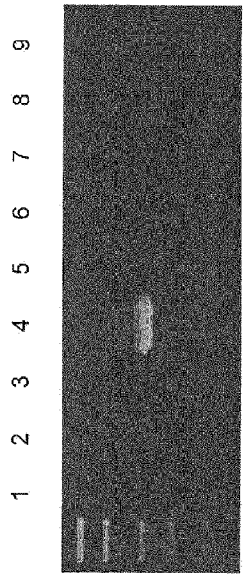


Fig. 28

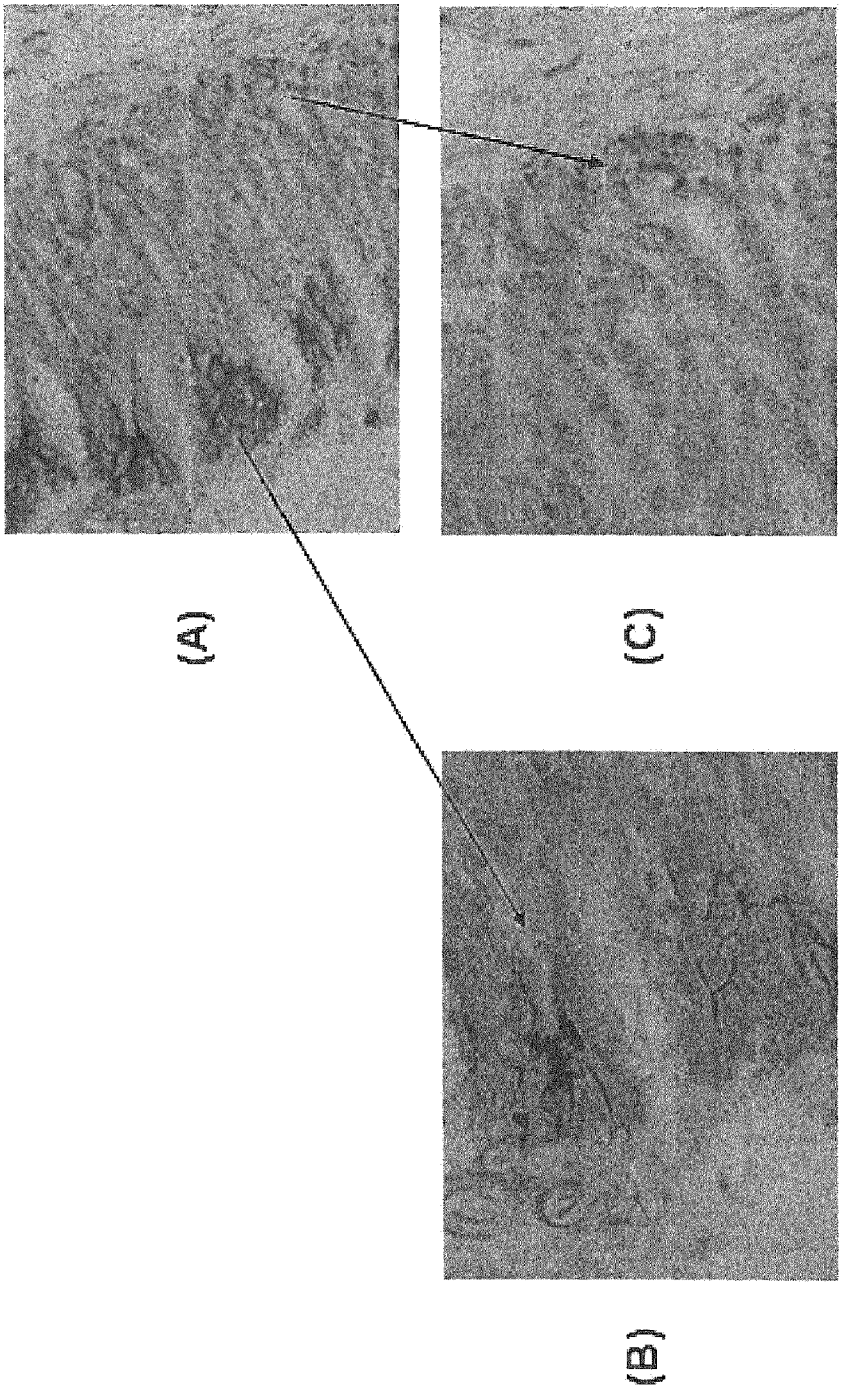


Fig. 29

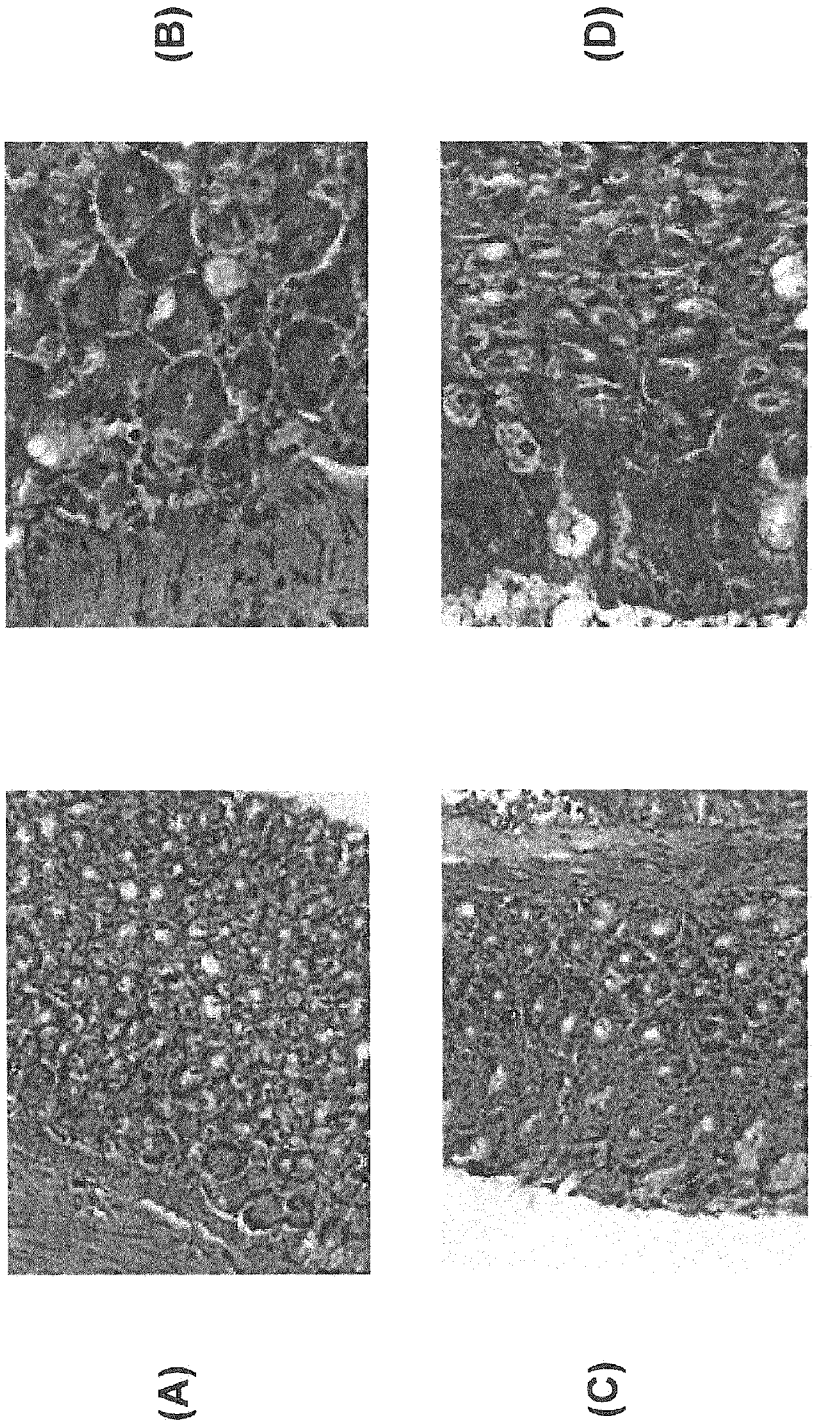


Fig. 30

Fig. 31A

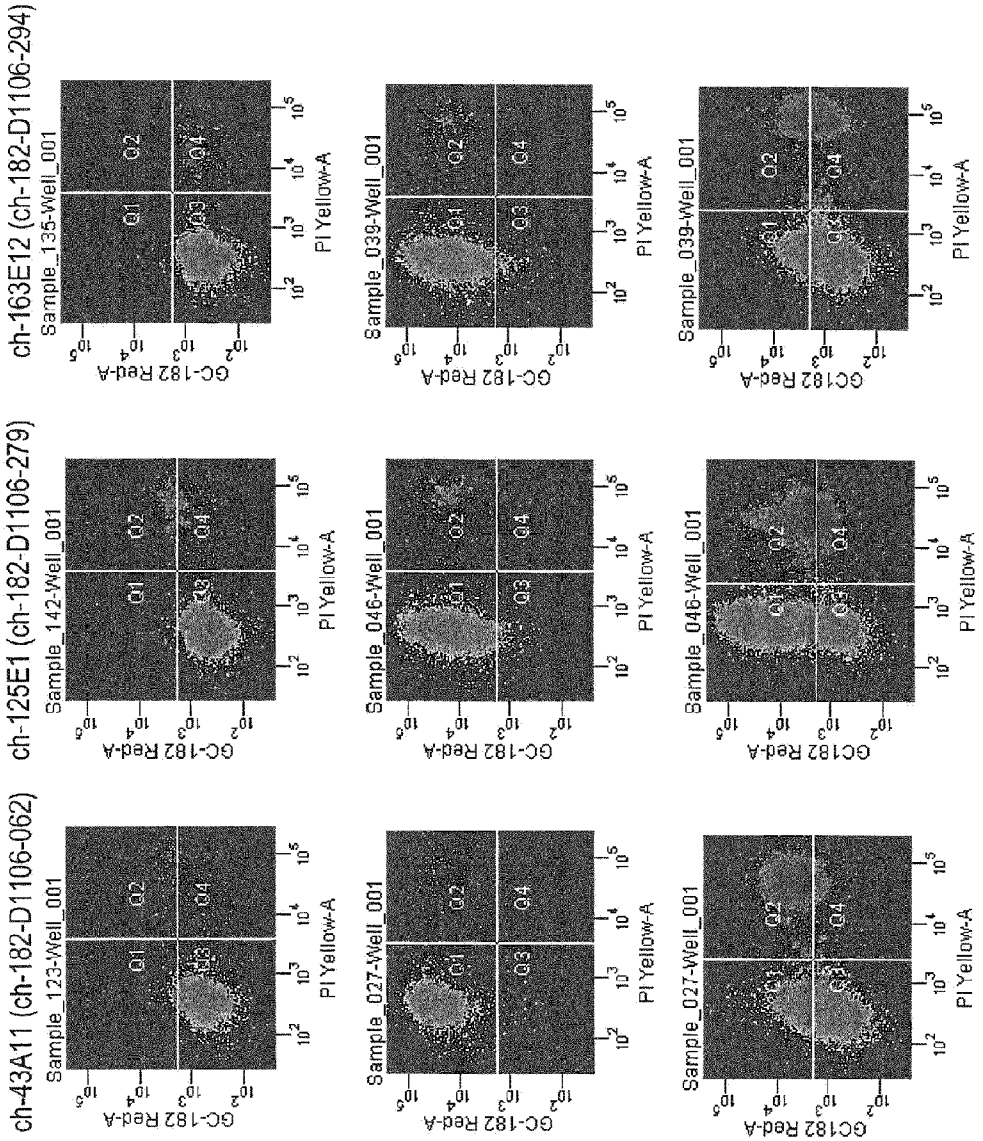
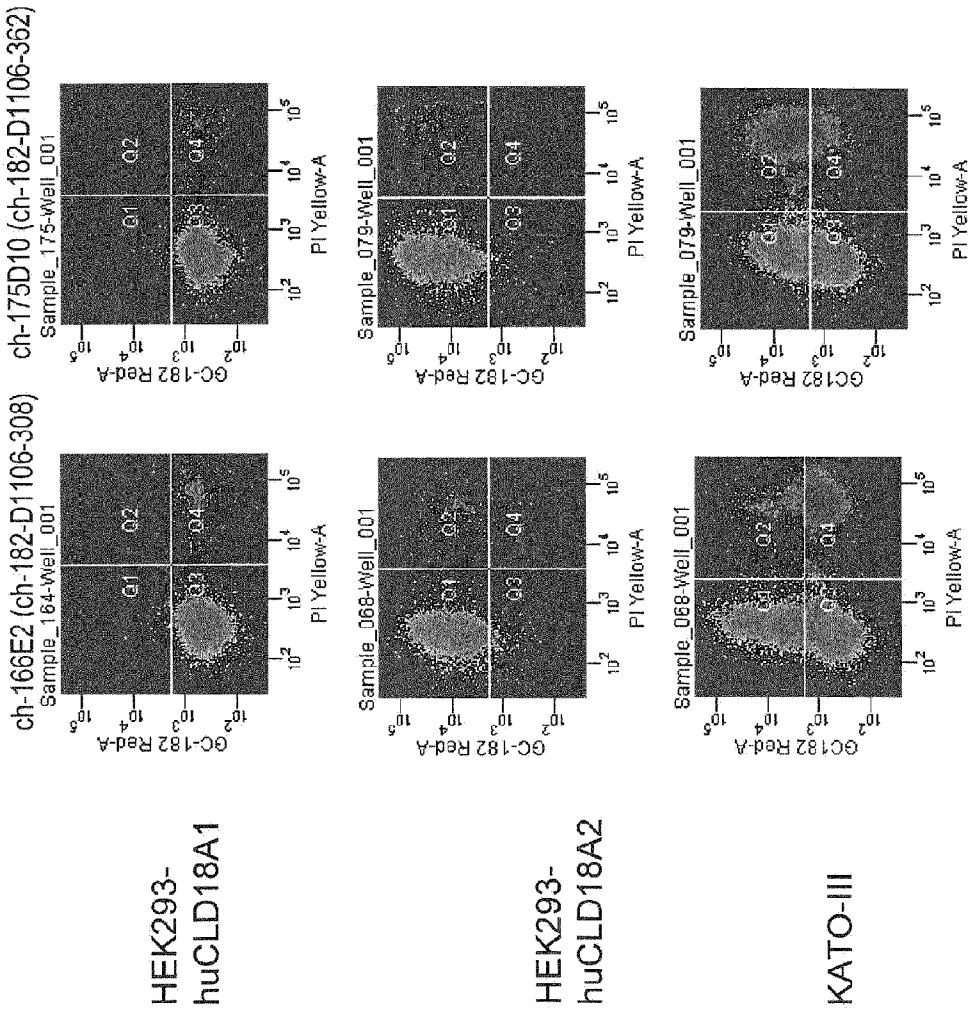

ch-43A11 (ch-182-D1106-062)
ch-125E1 (ch-182-D1106-279)
ch-163E12 (ch-182-D1106-294)
HEK293-huCLD18A1
HEK293-huCLD18A2
KATO-III
Sample_123-Well_001
Sample_142-Well_001
Sample_135-Well_001
Sample_027-Well_001
Sample_046-Well_001
Sample_039-Well_001
GC-182 Red-A
PI Yellow-A
Q1
Q2
Q3
Q4

Fig. 31B


ch-166E2 (ch-182-D1106-308)
ch-175D10 (ch-182-D1106-362)
Sample_164-Well_001
Sample_175-Well_001
Sample_068-Well_001
Sample_079-Well_001
Sample_068-Well_001
Sample_079-Well_001
GC-182 Red-A
PI Yellow-A
Q1
Q2
Q3
Q4
HEK293-huCLD18A1
HEK293-huCLD18A2
KATO-III

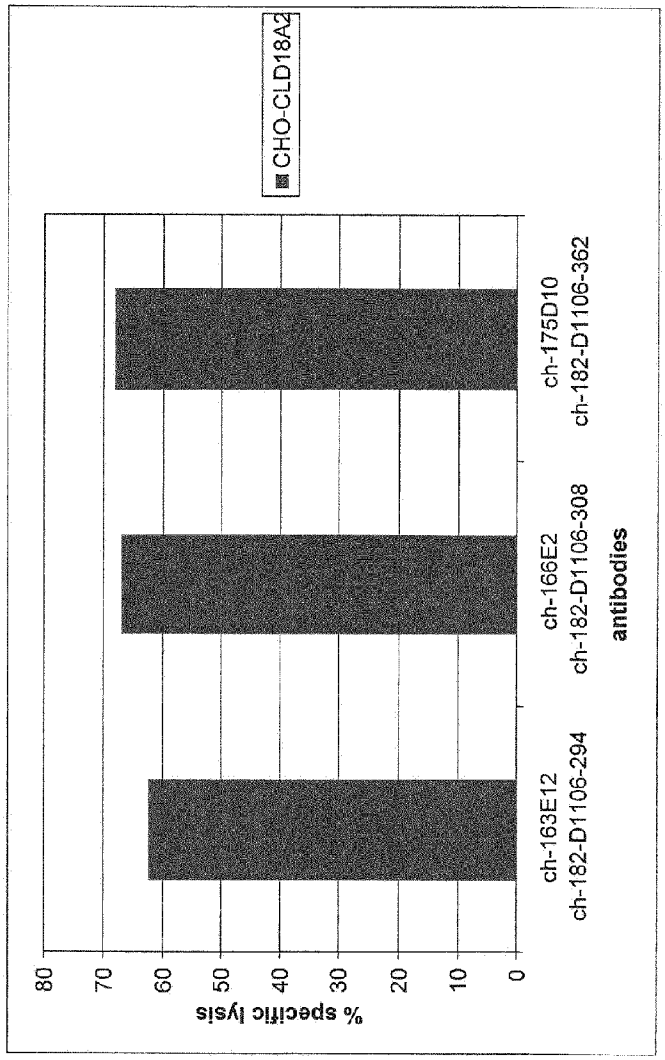

CHO-CLD18A2
% specific lysis
0
10
20
30
40
50
60
70
80
ch-163E12
ch-182-D1106-294
ch-166E2
ch-182-D1106-308
ch-175D10
ch-182-D1106-362
antibodies

Fig. 32

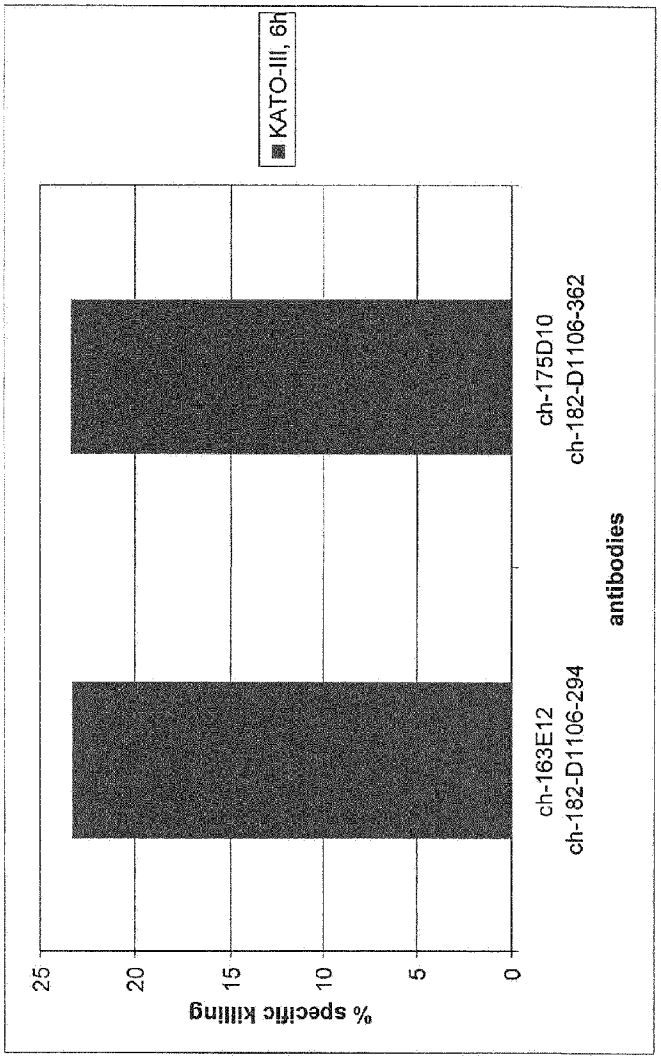

KATO-III, 6h
% specific killing
25
20
15
10
5
0
ch-163E12
ch-182-D1106-294
ch-175D10
ch-182-D1106-362
antibodies

Fig. 33

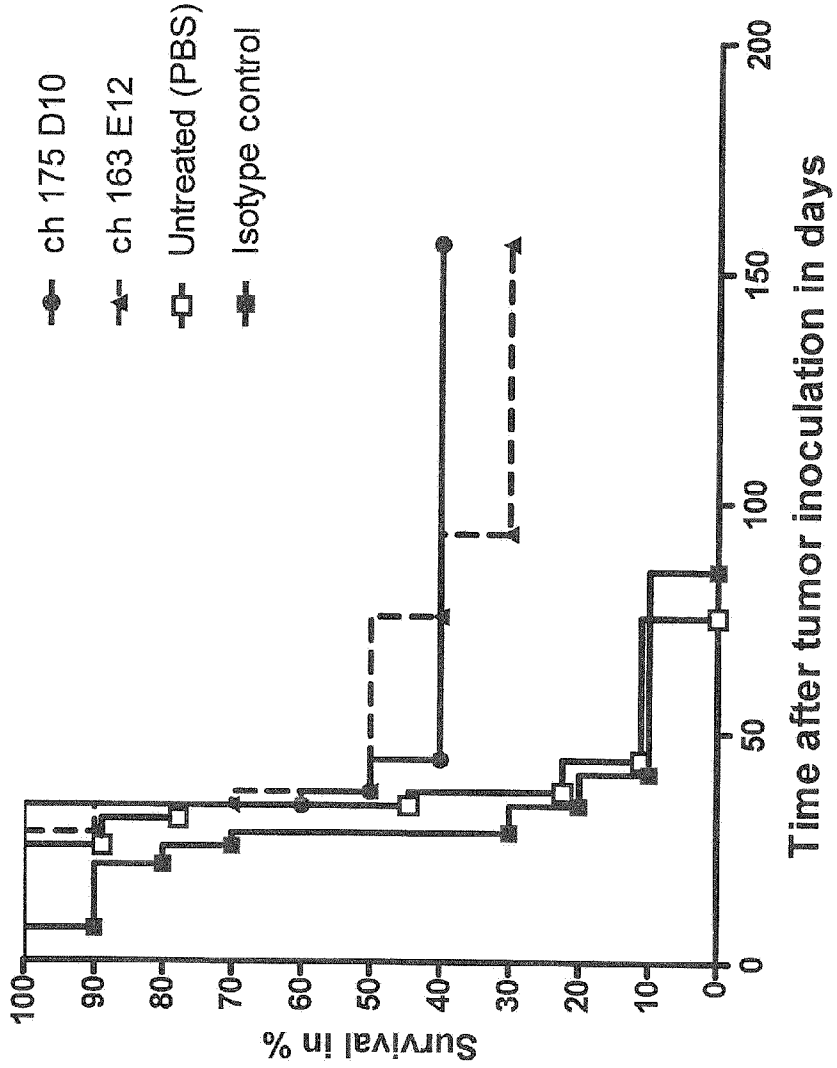

Kaplan-Meier survival plot
ch 175 D10
ch 163 E12
Untreated (PBS)
Isotype control
Survival in %
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
Time after tumor inoculation in days

Fig. 34

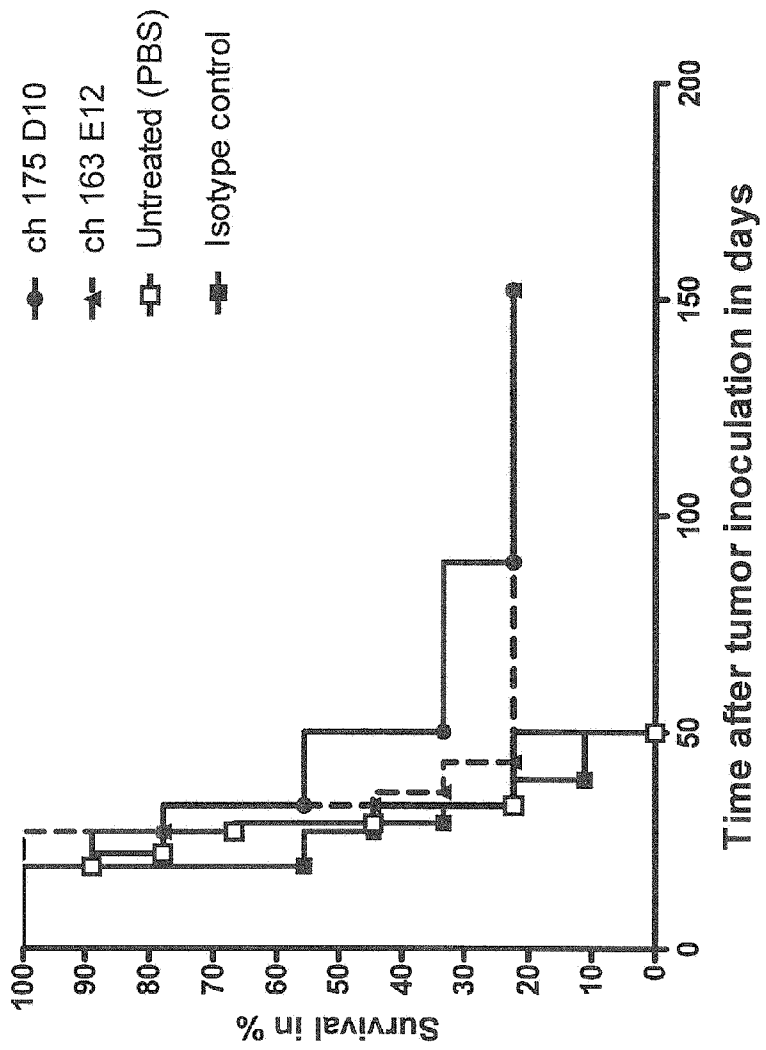
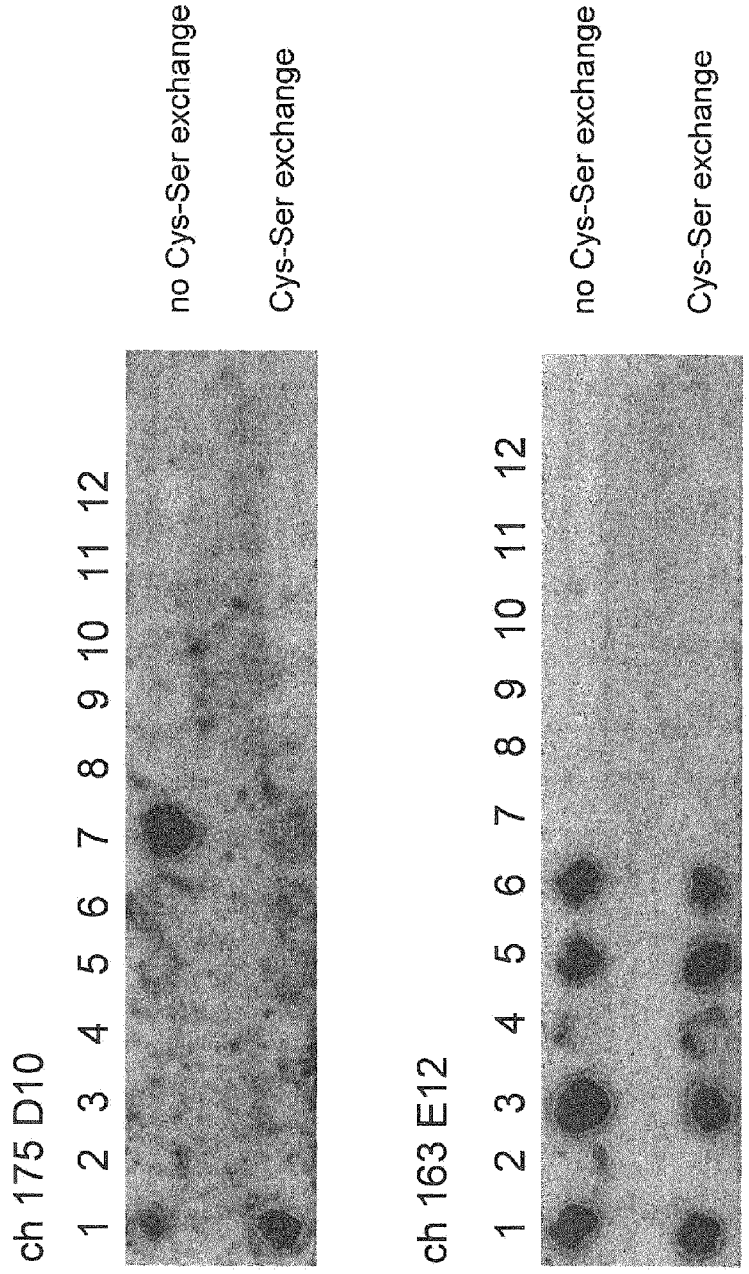

Kaplan-Meier survival plot
ch 175 D10
ch 163 E12
Untreated (PBS)
Isotype control
Survival in %
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
Time after tumor inoculation in days

Fig. 35

Fig. 36


ch 175 D10
1 2 3 4 5 6 7 8 9 10 11 12
no Cys-Ser exchange
Cys-Ser exchange
ch 163 E12
1 2 3 4 5 6 7 8 9 10 11 12
no Cys-Ser exchange
Cys-Ser exchange

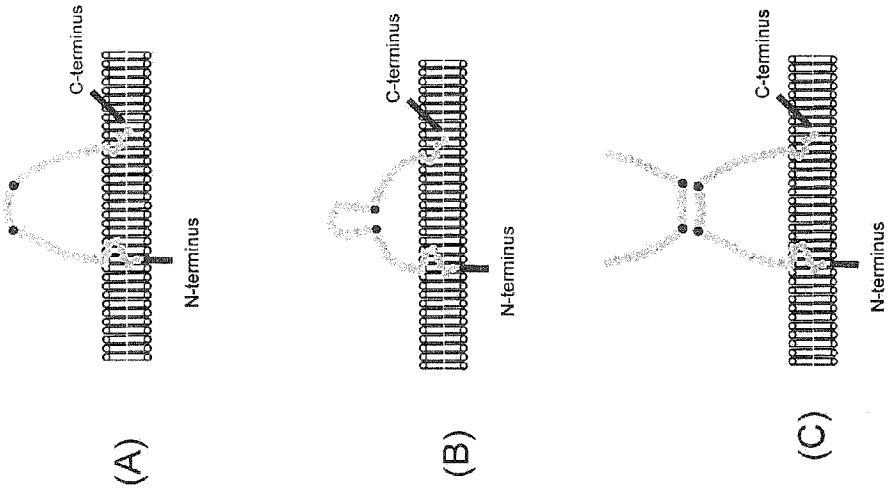
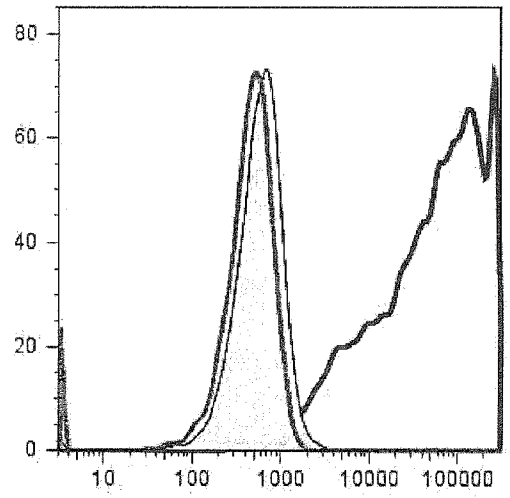
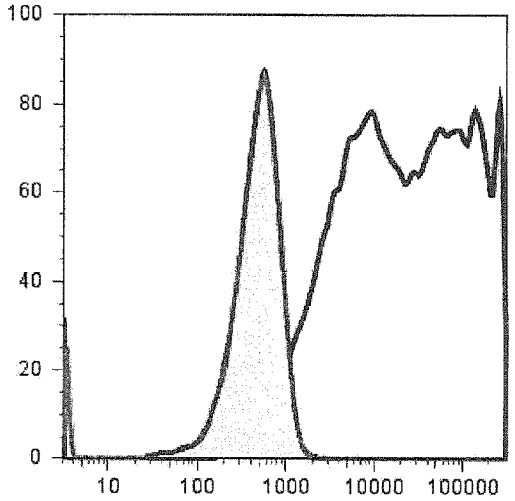

C-terminus
N-terminus
(A)
C-terminus
N-terminus
(B)
C-terminus
N-terminus
(C)

Fig. 37

Fig. 38A: ch-175D10

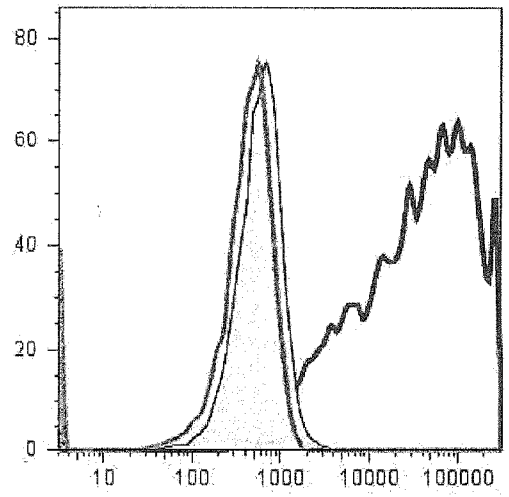




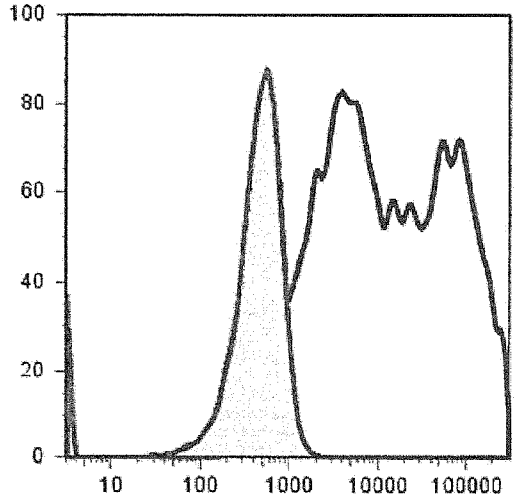
HEK293-human CLD18.A1
HEK293-human CLD18.A2
Isotype control staining

HEK293-murine CLD18.A1
HEK293-murine CLD18.A2
Isotype control staining

Fig. 38B: ch-163E12

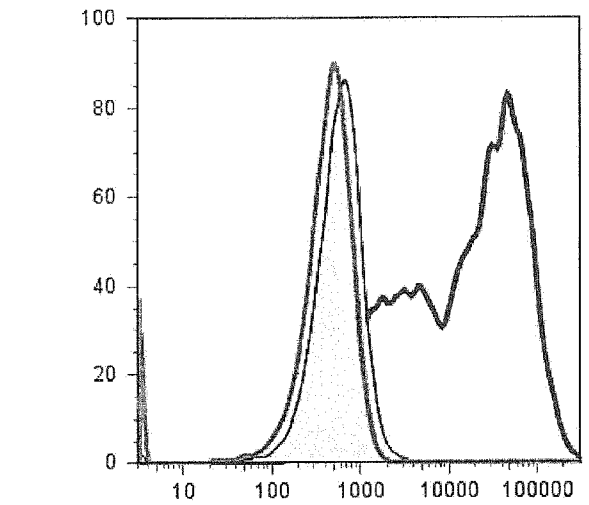


HEK293-human CLD18.A1
HEK293-human CLD18.A2
Isotype control staining

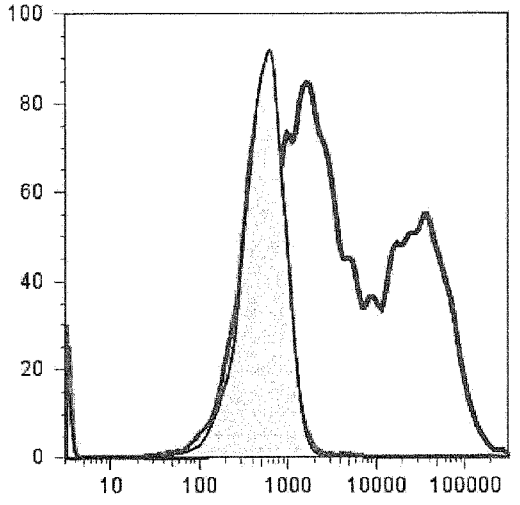


HEK293-murine CLD18.A1
HEK293-murine CLD18.A2
Isotype control staining

Fig. 38C: ch-125E1

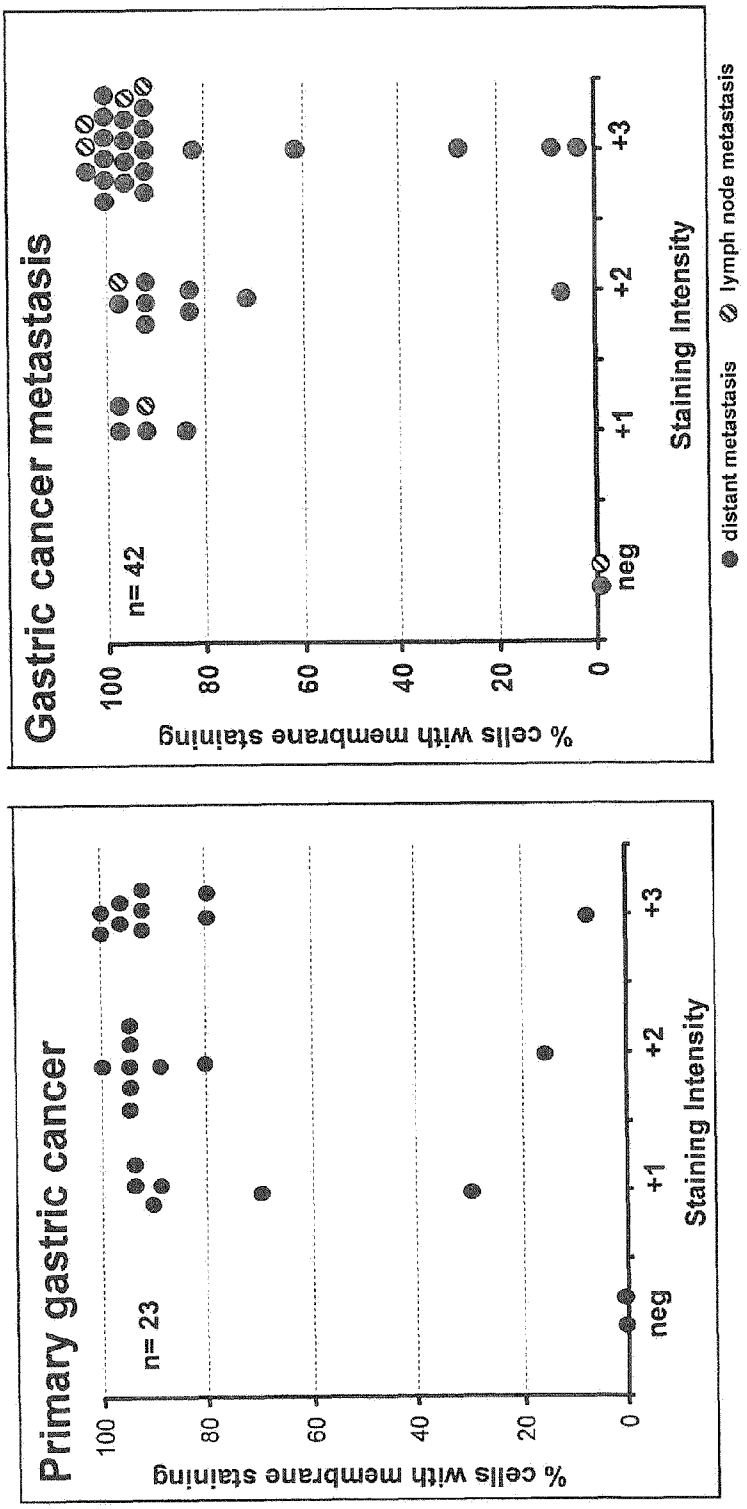


HEK293-human CLD18.A1
HEK293-human CLD18.A2
Isotype control staining



HEK293-murine CLD18.A1
HEK293-murine CLD18.A2
Isotype control staining

Fig. 39


Primary gastric cancer
n= 23
% cells with membrane staining
100
80
60
40
20
0
neg
+1
+2
+3
Staining Intensity
Gastric cancer metastasis
n= 42
% cells with membrane staining
100
80
60
40
20
0
neg
+1
+2
+3
Staining Intensity
distant metastasis
lymph node metastasis