

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau



WIPO | PCT



(10) International Publication Number

WO 2017/029511 A1

(43) International Publication Date

23 February 2017 (23.02.2017)

(51) International Patent Classification:

A61K 39/00 (2006.01) *A61K 35/17* (2015.01)
A61K 39/395 (2006.01) *C07K 16/30* (2006.01)

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(21) International Application Number:

PCT/GB2016/052563

(22) International Filing Date:

19 August 2016 (19.08.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1514874.5 20 August 2015 (20.08.2015) GB

(71) Applicant: AUTOLUS LTD [GB/GB]; Forest House, Depot Road, London W12 7RP (GB).

(72) Inventors: PULÉ, Martin; c/o Autolus Ltd, Forest House, Depot Road, London W12 7RP (GB). CORDOBA, Shaun; c/o Autolus Ltd, Forest House, Depot Road, London W12 7RP (GB). RIGHI, Matteo; c/o Autolus Ltd, Forest House, Depot Road, London W12 7RP (GB). SIL-LIBOURNE, James; c/o Autolus Ltd, Forest House, Depot Road, London W12 7RP (GB).

(74) Agent: WILLIAMS, Aylsa; D Young & Co LLP, 120 Holborn, London EC1N 2DY (GB).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- with sequence listing part of description (Rule 5.2(a))



WO 2017/029511 A1

(54) Title: CELL

(57) Abstract: The present invention provides a cell which comprises a first chimeric antigen receptor (CAR) and a second CAR, wherein the first and second CARs bind different epitopes on the same ligand. The cell may be used in a method for treating a disease, such as cancer.

CELL

FIELD OF THE INVENTION

5

The present invention relates to a chimeric-antigen receptor (CAR) expressing cell which is capable of recognising a ligand, for example a soluble ligand.

BACKGROUND TO THE INVENTION

10

Chimeric antigen receptors (CARs)

A number of immunotherapeutic agents have been described for use in cancer treatment, including therapeutic monoclonal antibodies (mAbs), bi-specific T-cell 15 engagers and chimeric antigen receptors (CARs).

Chimeric antigen receptors are proteins which graft the specificity of a monoclonal antibody (mAb) to the effector function of a T-cell. Their usual form is that of a type I transmembrane domain protein with an antigen recognizing amino terminus, a 20 spacer, a transmembrane domain all connected to a compound endodomain which transmits T-cell survival and activation signals.

The most common form of these molecules are fusions of single-chain variable fragments (scFv) derived from monoclonal antibodies which recognize a target 25 antigen, fused via a spacer and a trans-membrane domain to a signalling endodomain. Such molecules result in activation of the T-cell in response to recognition by the scFv of its target. When T cells express such a CAR, they recognize and kill target cells that express the target antigen. Several CARs have been developed against tumour associated antigens, and adoptive transfer 30 approaches using such CAR-expressing T cells are currently in clinical trial for the treatment of various cancers.

Various CARs have been tested *in vitro* and *in vivo* trials, as summarised in Table 1 below.

35

Table 1

Target antigen	Associated malignancy
α -Folate receptor	Ovarian cancer
CAIX	Renal cell carcinoma
CD19	B-cell malignancies
CD20	Lymphomas and B-cell malignancies
CD22	B-cell malignancies
CD30	Lymphomas
CD33	AML
CD44v7/8	Cervical carcinoma
CEA	Breast and colorectal cancer
EGP-2	Multiple malignancies
EGP-40	Colorectal cancer
erb-B2	Colorectal, breast and prostate cancer
erb-B 2,3,4	Breast and others
FBP	Ovarian cancer
Fetal acetylcholine receptor	Rhabdomyosarcoma
GD2	Neuroblastoma
GD3	Melanoma
Her2/neu	Medulloblastoma, osteosarcoma, Glioblastoma, lung malignancy
IL-13R-a2	Glioma, glioblastoma, medullablastoma
KDR	Tumor neovasculature
k-light chain	B-cell malignancies
LeY	Carcinomas, epithelial-derived tumours
L1 cell adhesion molecule	Neuroblastoma
MAGE-A1	Melanoma
Mesothelin	Various tumors
Murine CMV infected cells	Murine CMV
MUC1	Breast, Ovary
NKG2D ligands	Various tumors

Oncofetal antigen (h5T4)	Various tumors
PSCA	Prostate carcinoma
PSMA	Prostate/tumor vasculature
TAA targeted by mAb IgE	Various tumors
TAG-72	Adenocarcinomas
VEGF-R2	Tumor neovasculature

T-cell activation via segregation

5 T cell activation occurs because of size-based exclusion of inhibitory molecules from the synapse site, by a process known as kinetic segregation. T-cell receptor (TCR) and CARs cause T-cell signalling by stimulating tyrosine phosphorylation. In the resting T-cell, the molecules involved in this process are repeatedly colliding by means of diffusion. The TCR/CD3 complex is constantly being phosphorylated by Lck (membrane associated tyrosine kinase) and in turn continuously dephosphorylated by CD45 (tyrosine phosphatase). The continuous phosphorylation/dephosphorylation happens in a random manner and as a result the overall phosphorylation of TCR is low such that T-cell activation does not proceed.

10

15 The TCR/peptide-MHC complex or CAR-target cell ligand complex spans a short length. This forms small zones of close contact, from which the inhibitory CD45 and CD148 phosphatase molecules with ectodomains too large to fit in are excluded.

20

CD45 steric exclusion extends the phosphorylation half-lives of TCR/peptide-MHC complexes or CAR-target cell ligand complexes, which are trapped within the close-contact zone. Such prolonged phosphorylation of ITAMs by Lck kinase allows time for ZAP-70 recruitment, its activation by phosphorylation and subsequent phosphorylation of adaptor proteins LAT and SLP-76, leading to T-cell activation.

25 Central to the segregation mechanism of CAR-T-cell activation is the fact that the CAR binds an antigen on the surface of a target cell, creating the close-contact zone from which inhibitory phosphatases are excluded.

30 To date, CAR T-cells have therefore only been developed which recognise membrane-bound antigens on the target (e.g. tumour cell).

Soluble tumour antigens

5 Cancer development has been defined as a multistep process in which somatic cells first undergo an initiating event (i.e., environmental insult) and then a second or promoting event. The tumour microenvironment is an indispensable participant in the second part of this neoplastic process.

10 The tumour microenvironment is the product of a developing crosstalk between different cell types. For instance, in epithelial tumours, these cells include the invasive carcinoma and its stromal elements. Critical stromal elements include cancer-associated fibroblasts, which provide an essential communication network via secretion of growth factors and chemokines, inducing an altered ECM thus providing additional oncogenic signals enhancing cancer-cell proliferation and invasion. Active 15 contribution of tumor-associated stromal cells to cancer progression has been recognized. Stromal elements consists of the extracellular matrix (ECM) as well as fibroblasts of various phenotypes, and a scaffold composed of immune and inflammatory cells, blood and lymph vessels, and nerves.

20 For tumours to progress and develop into life threatening entities, they must develop four critical abilities. First, the ability to move, second the capacity to degrade tissue matrix (ECM), third the aptitude to survive in blood and finally the physical quality of being able to establish itself in a new tissue environment. The microenvironment is of critical importance for success in this processes.

25 The microenvironment of cancer cells provide the necessary signals that turn on transcription factors. Thus, it is the stromal or non-malignant cells that induce the requisite transcription programs allowing the necessary mesenchymal phenotypes to invade distant tissues and establish a new environment. The cancer cells must then 30 shut down the transcription factor programs and reconvert from mesenchymal to epithelial cells, thus recreating themselves from the core of primary tumour cells.

35 Tumour cells directly secrete a variety of proteins that include growth factors and ECM-degrading proteinases or induce the host to elaborate biomolecules that are able to degrade the matrix and its component adhesion molecules. The matrix degradation takes place in a region close to the tumour cell surface, where the amount of the active degradative enzymes outbalances the natural proteinase

inhibitors present in the matrix or that secreted by normal cells. Proteins secreted by tumour cell into the ECM microenvironment are therefore involved in cell adhesion, motility, intercellular communication and invasion.

- 5 A cancer may therefore be characterised by the presence of numerous soluble ligands in the tumour microenvironment, including proteins secreted by the tumour cells or surrounding non-cancerous (e.g. stromal cells) and molecule produced as a result of cancer activities such as matrix degradation.
- 10 Agents, such as monoclonal antibodies targeting such soluble ligands are currently in clinical development, but to date no cellular immunotherapy approaches have been able to access this valuable antigen source.

On-target off-tumour toxicity

- 15 It is relatively rare for the presence of a single antigen effectively to describe a cancer, which can lead to a lack of specificity.

- 20 Most cancers cannot be differentiated from normal tissues on the basis of a single antigen. Hence, considerable “on-target off-tumour” toxicity occurs whereby normal tissues are damaged by the therapy. For instance, whilst targeting CD20 to treat B-cell lymphomas with Rituximab, the entire normal B-cell compartment is depleted, whilst targeting CD52 to treat chronic lymphocytic leukaemia, the entire lymphoid compartment is depleted, whilst targeting CD33 to treat acute myeloid leukaemia, the entire myeloid compartment is damaged etc.
- 25

- 30 The predicted problem of “on-target off-tumour” toxicity has been borne out by clinical trials. For example, an approach targeting ERBB2 caused death to a patient with colon cancer metastatic to the lungs and liver. ERBB2 is over-expressed in colon cancer in some patients, but it is also expressed on several normal tissues, including heart and normal vasculature.

- 35 For some cancers, targeting the presence of two cancer antigens may be more selective and therefore effective than targeting one. For example, B-chronic lymphocytic leukaemia (B-CLL) is a common leukaemia which is currently treated by targeting CD19. This treats the lymphoma but also depletes the entire B-cell compartment such that the treatment has a considerable toxic effect. B-CLL has an

unusual phenotype in that CD5 and CD19 are co-expressed. By targeting only cells which express CD5 and CD19, it would be possible to considerably reduce on-target off-tumour toxicity.

5 If it were possible to target soluble ligands using immunotherapy approaches, then it would be possible to target a cell based on the presence of a membrane antigen in combination with the presence of a soluble ligand, such as a chemokine, cytokine or metabolite which is characteristic of tumour or non-tumour tissue. This would also be expected to considerably reduce on-target off-tumour toxicity.

10

DESCRIPTION OF THE FIGURES

Figure 1: A schematic diagram illustrating that a soluble ligand causes no aggregation with a single CAR T-cell.

15

Figure 2: A schematic diagram illustrating the predicted aggregation with soluble ligand with a dual CAR platform where both CARs recognise the same ligand.

20

Figure 3: A schematic diagram illustrating the predicted aggregation with soluble ligand with a dual CAR platform where both CARs recognise the same ligand and where one CAR is multivalent.

25

Figure 4: A schematic diagram illustrating the model used to show proof-of-concept. The ligand used was ROR-1 and the first and second receptors were R12 and R11 respectively.

Figure 5: A schematic diagram illustrating the predicted aggregation with ROR-1 using the model system tested in the Examples.

30

Figure 6: A schematic diagram illustrating the predicted aggregation with ROR-1 using the model system tested in the Examples where one CAR is multivalent.

35

Figure 7: A graph showing IL-2 secretion in the presence of soluble ligand (ROR-1). BW5 T-cells were transduced with either a single CAR (R11 or R12 with either an Fc or CD8STK or COMP spacer) or with two CARs. These T-cells were co-cultured with soluble ROR-1 ligand and IL-2 was detected after 24h.

5 **Figure 8:** A graph showing IL-2 secretion in the presence of an immobilized ligand. BW5 T-cells were transduced with either a single CAR (R11 or R12 with either an Fc or CD8STK or COMP spacer) or with two CARs. These T-cells were co-cultured with anti-His beads that were pre-coated with soluble His tagged ROR-1 ligand and IL-2 was detected after 24h.

10 **Figure 9:** A schematic diagram showing an example of a “split” CAR system. Binding of a cell surface antigen, such as PSMA, by the third CAR provides T-cell activatory signal 1 via the TCR zeta endodomain. Binding of a soluble ligand, such as PSA, by the first and second CARs provides T cell activatory signals 2 and 3 via CD28 and OX40 endodomains. The presence of both the cell surface antigen (eg PSMA) and the soluble ligand (e.g. PSA) provides all three signals and leads to T-cell activation.

15 **Figure 10:** A schematic diagram showing a CAR system, where the first and/or second CARs inhibit(s) signalling from the third CAR. Binding of a cell surface antigen (“Ligand A” e.g. PSMA) by the third CAR leads to T cell signalling. However, binding of a soluble ligand (e.g. IL6) by the first and second CARs leads to aggregation-induced phosphorylation and inhibition of signalling.

20 **Figure 11:** A schematic diagram showing a “TanCAR” system in which the first CAR comprises two antigen binding domains, one (“Binder A”) which binds a cell surface antigen (“Ligand A”, e.g. PSMA) and one (“Binder B1”) which binds a soluble ligand (“Ligand B”, e.g. IL-6). The second CAR binds the soluble ligand (“Ligand B”, e.g. IL-6) through its antigen-binding domain (“Binder B2”). The second CAR has an endodomain which inhibits T cell signalling. Binding of a cell surface antigen (“Ligand A” e.g. PSMA) by the first CAR leads to T cell signalling. However, binding of a soluble ligand (e.g. IL6) by the first and second CARs causes the inhibitory endodomain on the second CAR to colocalise with the activating endodomain on the first CAR, leading to inhibition of signalling.

25 **Figure 12:** A schematic diagram showing an “AND gate” system, in which the first and/or second CAR comprises an inhibitory endodomain with fast kinetics (eg CD148 endodomain). In the absence of the soluble ligand, the inhibitory endodomain constitutively inhibits the activating endodomain on the third CAR. In the presence of soluble ligand, the first and second CARs aggregate and segregate from the third CAR, allowing T-cell signalling to occur.

Figure 13: A schematic diagram showing an alternative “AND gate” system, in which the first CAR comprises two antigen binding domains, one (“Binder A”) which binds a cell surface antigen (“Ligand A”, e.g. PSMA) and one (“Binder B1”) which binds a soluble ligand (“Ligand B”, e.g. PSA). The second CAR binds the soluble ligand (“Ligand B”, e.g. PSA) through its antigen-binding domain (“Binder B2”). The first CAR does not comprise a functional T-cell activating endodomain, whereas the second CAR does comprise a functional T-cell activating endodomain. In the absence of the soluble ligand, binding of the cell surface antigen does not lead to cell signalling due to the absence of a TCR zeta chain. In the presence of the soluble ligand, the first and second CARs co-localise and binding of the cell surface antigen by the first CAR does lead to cell signalling. In order to prevent signalling in the absence of the cell-surface ligand, the second CAR may be monomeric, which may be achieved using a monomeric spacer such as one based on CD22.

Figure 14: An aggregation-based AND gate only signals in the presence of membrane-bound antigen (CD19) and soluble ligand (ROR1).

Figure 15: A graph to show IL-2 secretion in the presence of the soluble ligand PSA. BW5 T-cells were transduced with a vector expressing two CARs, which bind different epitopes of PSA. One CAR had an antigen binding domain based on 5A5A5 and one CAR having an antigen binding domain based on 5D3D11 (aPSA-A5-CD8STK-CD28TM-z_aPSA-D11-HL-Hinge-CD28tmZ or aPSA-D11-CD8STK-CD28TM-z_aPSA-A5-HL-Hinge-CD28tmZ). These T-cells were co-cultured with soluble PSA ligand and IL-2 was detected after 24h.

25

SUMMARY OF ASPECTS OF THE INVENTION

The present inventors have found that it is possible to target a soluble ligand using a CAR approach by using a cell which comprises two CARs each recognising an epitope on the same soluble ligand.

Because the CARs recognise distinct epitopes on the same ligand, the presence of ligand causes aggregation of ligand-associated CARs on the surface of the cell. The present invention therefore, in effect, turns T-cell signalling from a segregation- to an aggregation-based process.

Thus, in a first aspect, the present invention provides a cell which comprises a first chimeric antigen receptor (CAR) and a second CAR, wherein the first and second CARs bind different epitopes on the same ligand.

- 5 The ligand may be a soluble ligand, such as a cytokine, chemokine or metabolite. The soluble ligand may, for example be selected from the following group: transforming growth factor beta (TGF- β), prostate-specific antigen (PSA), carcinoembryonic antigen (CEA) and vascular endothelial growth factor (VEGF).
- 10 Each CAR may comprise:
 - (i) an antigen-binding domain;
 - (ii) a spacer; and
 - (iii) a trans-membrane domain.
- 15 The spacers of the first and second CARs may be different.

The spacers of the first and/or second CAR(s) may be trimeric or multi-valent.

The cell may comprise a third CAR which binds a cell surface antigen.

- 20 The first aspect of the invention also provides five separate embodiments, each of which relate to particular arrangements of signalling in the present (or absence) of a cell-surface antigen and a ligand such as a soluble ligand.
- 25 In the first embodiment, the first and/or second and third CARs each comprise:
 - (i) an antigen-binding domain;
 - (ii) a trans-membrane domain; and
 - (iii) an endodomainand the endodomains of the third CAR and the first and/or second CAR(s) are complementary, such that cell activation occurs when the ligand is bound by the first and second CARs and the cell surface antigen is bound by the third CAR.

- 30 In this embodiment, the third CAR may comprise a CD3 zeta endodomain, and the first and/or second CAR(s) may comprise a CD28 endodomain and a OX40 or 41BB endodomain.

In this embodiment, the third CAR may bind prostate-specific membrane antigen (PSMA) and the first and second CARs may bind prostate-specific antigen (PSA).

5 In the second embodiment, the first and/or second CAR(s) comprise(s) an inhibitory endodomain, such that when the first and second CARs bind the ligand, cell activation caused by the third CAR binding the cell surface antigen is inhibited.

In the third embodiment the first CAR comprises two antigen binding domains: one which binds the soluble ligand; and one which binds a cell-surface antigen.

10 In this embodiment the second CAR comprises an inhibitory endodomain, such that when the first and second CARs bind the soluble ligand, cell activation caused by the first CAR binding the cell surface antigen is inhibited.

15 The inhibitory endodomain for the second or third embodiment may be or comprise the catalytic domain of PTPN6 or an Immunoreceptor Tyrosine-based Inhibition motif (ITIM).

For the second or third embodiment, the first and second CARs may bind IL-6.

20 In a fourth embodiment the first and/or second CAR(s) comprise(s) an inhibitory endodomain, such that:

in the absence of the ligand, cell activation caused by the third CAR binding the cell surface antigen is inhibited; and

25 in the presence of ligand, the first and second CARs aggregate and segregate from the third CAR, so that signaling can occur when the third CAR binds the cell surface antigen.

30 In the fourth embodiment the inhibitory endodomain may be or comprise the endodomain of CD45 or CD148.

35 In the fifth embodiment the first CAR lacks a functional endodomain and the second CAR is monomeric and comprises a functional endodomain, such that binding of the soluble ligand causes co-localisation of the first and second CARs and enables T-cell signalling to occur when the first CAR binds the cell surface antigen.

The second CAR may comprise a monomeric spacer, which may, for example, comprise one or more Ig domains from CD22.

In the fifth embodiment the functional endodomain on the second CAR may comprise
5 the CD3-zeta endodomain.

In a second aspect, the present invention provides a nucleic acid construct which comprises a first nucleic acid sequence encoding a first CAR as defined above; and a second nucleic acid sequence encoding a second CAR as defined above.

10

The nucleic acid construct may have the following structure:

AgB1-spacer1-TM1-endo1-coexpr-AbB2-spacer2-TM2-endo2

15 in which

AgB1 is a nucleic acid sequence encoding the antigen-binding domain of the first CAR;

spacer 1 is a nucleic acid sequence encoding the spacer of the first CAR;

TM1 is a nucleic acid sequence encoding the transmembrane domain of the first
20 CAR;

endo 1 is a nucleic acid sequence encoding the endodomain of the first CAR;

coexpr is a nucleic acid sequence enabling co-expression of both CARs

AgB2 is a nucleic acid sequence encoding the antigen-binding domain of the second CAR;

25 spacer 2 is a nucleic acid sequence encoding the spacer of the second CAR;

TM2 is a nucleic acid sequence encoding the transmembrane domain of the second CAR;

endo 2 is a nucleic acid sequence encoding the endodomain of the second CAR;

which nucleic acid construct, when expressed in a T cell, encodes a polypeptide

30 which is cleaved at the cleavage site such that the first and second CARs are co-expressed at the T cell surface.

“coexpr” may encode a sequence comprising a self-cleaving peptide.

35 Alternative codons may be used in regions of sequence encoding the same or similar amino acid sequences, in order to avoid homologous recombination.

The nucleic acid construct may also comprise a nucleic acid sequence encoding a third CAR as defined above.

5 In a third aspect the present invention provides a vector comprising a nucleic acid construct according to the second aspect of the invention.

The vector may, for example, be a retroviral vector or a lentiviral vector or a transposon.

10 In a fourth aspect the present invention provides a kit which comprises:

- i) a vector comprising a nucleic acid sequence encoding a first CAR as defined above; and
- ii) a vector comprising a nucleic acid sequence encoding a second CAR as defined above.

15

The kit may also comprise a vector comprising a nucleic acid sequence encoding a third CAR as defined above.

20 In a fifth aspect, the present invention provides a method for making a cell according to the first aspect of the invention, which comprises the step of introducing: a nucleic acid construct according to the second aspect of the invention; a vector according to the third aspect of the invention; or a kit of vectors according to the fourth aspect of the invention, into a cell.

25 In the method of the fifth aspect of the invention, the cell may be from a sample isolated from a subject.

In a sixth aspect, the present invention provides a pharmaceutical composition comprising a plurality of cells according to the first aspect of the invention.

30

In a seventh aspect, the present invention provides a method for treating and/or preventing a disease, which comprises the step of administering a pharmaceutical composition according to the sixth aspect of the invention to a subject.

35 The method may comprise the following steps:

- (i) isolation of a cell-containing sample from a subject;

(ii) transduction or transfection of the cells with: a nucleic acid construct according to the second aspect of the invention; a vector according to the third aspect of the invention; or a kit of vectors according to the fourth aspect of the invention; and
(iii) administering the cells from (ii) to a the subject.

5

The sample may be a T-cell containing sample.

The disease may be a cancer.

10 In an eighth aspect, the present invention provides a pharmaceutical composition according to the sixth aspect of the invention for use in treating and/or preventing a disease.

15 In a ninth aspect, the present invention provides the use of a cell according to the first aspect of the invention in the manufacture of a medicament for treating and/or preventing a disease.

The disease may be a cancer.

20 DETAILED DESCRIPTION

CHIMERIC ANTIGEN RECEPTORS (CARs)

Classical CARs are chimeric type I trans-membrane proteins which connect an extracellular antigen-recognizing domain (binder) to an intracellular signalling domain (endodomain). The binder is typically a single-chain variable fragment (scFv) derived from a monoclonal antibody (mAb), but it can be based on other formats which comprise an antibody-like or ligand-based antigen binding site. A trans-membrane domain anchors the protein in the cell membrane and connects the spacer to the endodomain.

Early CAR designs had endodomains derived from the intracellular parts of either the γ chain of the Fc ϵ R1 or CD3 ζ . Consequently, these first generation receptors transmitted immunological signal 1, which was sufficient to trigger T-cell killing of cognate target cells but failed to fully activate the T-cell to proliferate and survive. To overcome this limitation, compound endodomains have been constructed: fusion of the intracellular part of a T-cell co-stimulatory molecule to that of CD3 ζ results in

second generation receptors which can transmit an activating and co-stimulatory signal simultaneously after antigen recognition. The co-stimulatory domain most commonly used is that of CD28. This supplies the most potent co-stimulatory signal - namely immunological signal 2, which triggers T-cell proliferation. Some receptors 5 have also been described which include TNF receptor family endodomains, such as the closely related OX40 and 41BB which transmit survival signals. Even more potent third generation CARs have now been described which have endodomains capable of transmitting activation, proliferation and survival signals.

10 CAR-encoding nucleic acids may be transferred to T cells using, for example, retroviral vectors. In this way, a large number of antigen-specific T cells can be generated for adoptive cell transfer. When the CAR binds the target-antigen, this results in the transmission of an activating signal to the T-cell it is expressed on. Thus the CAR directs the specificity and cytotoxicity of the T cell towards cells 15 expressing the targeted antigen.

20 The cell of the present invention comprises a first chimeric antigen receptor (CAR) and a second CAR. The cell may also comprise third and optionally subsequent CARs.

25 The CARs may comprise an antigen-binding domain, a spacer domain, a transmembrane domain and an endodomain. The endodomain may comprise or associate with a domain which transmit T-cell activation signals.

25 ANTIGEN BINDING DOMAIN

The antigen-binding domain is the portion of a CAR which recognizes antigen.

30 Numerous antigen-binding domains are known in the art, including those based on the antigen binding site of an antibody, antibody mimetics, and T-cell receptors. For example, the antigen-binding domain may comprise: a single-chain variable fragment (scFv) derived from a monoclonal antibody; a natural ligand of the target antigen; a peptide with sufficient affinity for the target; a single domain binder such as a camelid; an artificial binder single as a Darpin; or a single-chain derived from a T-cell receptor.

35 The antigen-binding domain may bind an epitope on a soluble or a membrane-bound ligand, as defined below.

The term “ligand” is used synonymously with “antigen” to mean an entity which is specifically recognised and bound by the antigen-binding domain of a CAR.

5 SOLUBLE LIGAND

The term “soluble ligand” is used to indicate a ligand or antigen which is not part of or attached to a cell but which moves freely in the extracellular space, for example in a bodily fluid of the tissue of interest. The soluble ligand may exist in a cell-free state in
10 the serum, plasma or other bodily fluid of an individual.

The soluble ligand may, for example, be a cytokine, chemokine or metabolite.

Cytokines are small proteins (~5–20 kDa) that are important in cell signalling. They
15 are released by cells and affect the behaviour of other cells. Cytokines include chemokines, interferons, interleukins, lymphokines and tumour necrosis factor. Cytokines are produced by a broad range of cells, including immune cells like macrophages, B lymphocytes, T lymphocytes and mast cells, as well as endothelial cells, fibroblasts, and various stromal cells.

20 Cytokines act through receptors, and are important in health and disease, specifically in host responses to infection, immune responses, inflammation, trauma, sepsis, cancer, and reproduction. Chemokines mediate chemoattraction (chemotaxis) between cells.

25 Cytokines are thought to play key roles both in the immune response to cancer and the pathology of cancer. Cytokines directly stimulate immune effector cells and stromal cells at the tumour site and enhance tumour cell recognition by cytotoxic effector cells. Numerous animal tumour model studies have demonstrated that
30 cytokines have broad anti-tumor activity and this has been translated into a number of cytokine-based approaches for cancer therapy. Recent years have seen a number of cytokines, including GM-CSF, IL-7, IL-12, IL-15, IL-18 and IL-21, enter clinical trials for patients with advanced cancer.

35 There is ongoing pre-clinical work supporting the neutralization of suppressive cytokines, such as IL-10 and TGF- β in promoting anti-tumour immunity. An advantage of targeting an immune-suppressive cytokine with a CAR cell of the

present invention is that the CAR is effective in two ways: firstly by being activated by a cytokine which is characteristic of the disease and secondly by sequestering at least a protein of the circulating cytokine, thereby lessening its immune-suppressive effect.

5

The soluble ligand may be associated with the presence or pathology of a particular disease, such as cancer.

10 The soluble ligand may be part of the cancer secretome, i.e. the collection of factors secreted by a tumour, be it from cancer stem cells, non-stem cells or the surrounding stroma. The soluble ligand may be secreted by tumour cells. The soluble ligand may, for example, be selected from the following group: TGF β , PSA, CEA and VEGF.

15 The soluble ligand may be characteristic of a disease or of diseased tissue. It may be found exclusively, or at a higher level in a subject having the disease vs a healthy subject; or in diseased tissue vs healthy tissue. The soluble ligand may be expressed at at least a 2-fold, 5-fold, 10-fold, 100-fold, 1000-fold, 10,000-fold or 100,000 fold higher level a subject having the disease vs a healthy subject; or in diseased tissue vs healthy tissue.

20

TGF BETA

The soluble ligand may be TGF β .

25 Transforming growth factor beta (TGF- β) is a secreted protein that controls proliferation, cellular differentiation, and other functions in cells. It is a cytokine which plays a role in immunity and various diseases including cancer, bronchial asthma, lung fibrosis, heart disease, diabetes, Multiple Sclerosis and AIDS.

30 TGF- β is secreted by many cell types, including macrophages, in a latent form in which it is complexed with two other polypeptides, latent TGF-beta binding protein (LTBP) and latency-associated peptide (LAP). Serum proteinases such as plasmin catalyze the release of active TGF- β from the complex. This often occurs on the surface of macrophages where the latent TGF- β complex is bound to CD36 via its ligand, thrombospondin-1 (TSP-1). Inflammatory stimuli that activate macrophages enhance the release of active TGF- β by promoting the activation of plasmin.

35

Macrophages can also endocytose IgG-bound latent TGF- β complexes that are secreted by plasma cells and then release active TGF- β into the extracellular fluid.

TGF- β exists in at least three isoforms: TGF- β 1, TGF- β 2 and TGF- β 3. Information on 5 the sequence and characteristics of TGF- β 1, TGF- β 2 and TGF- β 3 are available from omim.org, entries 190180, 190220 and 190230 respectively.

TGF- β acts as an antiproliferative factor in normal epithelial cells and at early stages 10 of oncogenesis. Cancerous cells increase their production of TGF- β , which also acts on surrounding cells.

In normal cells, TGF- β , acting through its signaling pathway, stops the cell cycle at 15 the G1 stage to stop proliferation, induce differentiation, or promote apoptosis. When a cell is transformed into a cancer cell, parts of the TGF- β signaling pathway are mutated, and TGF- β no longer controls the cell. These cancer cells proliferate. The surrounding stromal cells (fibroblasts) also proliferate. Both cells increase their production of TGF- β . This TGF- β acts on the surrounding stromal cells, immune cells, 20 endothelial and smooth-muscle cells. It causes immunosuppression and angiogenesis, which makes the cancer more invasive. TGF- β also converts effector T-cells, which normally attack cancer with an inflammatory (immune) reaction, into regulatory (suppressor) T-cells, which turn off the inflammatory reaction.

TGF- β is therefore an attractive target for the soluble ligand-recognising CAR of the 25 present invention because a) upregulated expression of TGF- β is characteristic of a number of cancers; and b) sequestering free TGF- β by a CAR-expressing cell may reduce the amount of TGF- β in circulation and its associated immunosuppressive, angiogenic and anti-inflammatory effects.

The first or second CAR of the cell of the invention may comprise a binding domain 30 based on fresolimumab.

Fresolimumab (GC1008) is a human monoclonal antibody which binds to and inhibits all isoforms of the TGF- β . Fresolimumab has been used in the treatment of idiopathic pulmonary fibrosis (IPF), focal segmental glomerulosclerosis, and cancer e.g. kidney 35 cancer and melanoma.

The antigen-binding domain of first or second CAR may, for example, comprise the 6 CDRs or the VH and/or VL domain(s) from Fresolimumab.

PROSTATE-SPECIFIC ANTIGEN (PSA)

5

The soluble ligand may be prostate-specific antigen (PSA).

10 Prostate-specific antigen (PSA), also known as gamma-seminoprotein or kallikrein-3 (KLK3), is a glycoprotein enzyme encoded in humans by the KLK3 gene. PSA is a member of the kallikrein-related peptidase family and is secreted by the epithelial cells of the prostate gland.

PSA is present in small quantities in the serum of men with healthy prostates, but is elevated in individuals with prostate cancer and other prostate disorders.

15

PSA is a 237-residue glycoprotein and is activated by KLK2. Its physiological role is the liquefaction of the coagulum components of the semen leading to liberation of spermatozoa. In cancer, PSA may participate in the processes of neoplastic growth and metastasis.

20

PSA is a chymotrypsin-like serine protease with a typical His-Asp-Ser triad and a catalytic domain similar to those of other kallikrein-related peptidases. The crystal structure of PSA has been obtained i) in complex with the monoclonal antibody (mAb) 8G8F5 and ii) in a sandwich complex with two mAbs 5D5A5 and 5D3D11 (Stura et al 25 (J. Mol. Biol. (2011) 414:530-544).

Various monoclonal antibodies are known, including clones 2G2-B2, 2D8-E8, IgG1/K described in Bavat et al Avicenna J. Med. Biotechnol. 2015, 7:2-7; andLeinonen (2004) 289:157-67

30

The antigen-binding domain of first or second CAR may, for example, comprise the 6 CDRs or the VH and/or VL domain(s) from a PSA-binding mAb such as 8G8F5, 5D5A5 or 5D3D11

35 The amino acid sequences for 5D3D11 and 5D5A5 VH and VL are given below. The complementarity determining regions (CDRs) are highlighted in bold.

5D3D11 VH (SEQ ID No. 1)

QVQLQQSGPELVKPGASVKISCKVSGYAISSSSWMNWVKQRPGQGLEWIGRIYPGD
GDTKYNGKFKDKATLTVDKSSSTAYMQLSSLTSVDSAVYFCARDGYRYYFDYWGQ
GTSVTVSS

5

5D3D11 VL (SEQ ID No. 2)

DIVMTQTAPSVFVTPGESVSISCRSSKSLLHSNGNTYLYWFLQRPGQSPQLLIYRMS
NLASGVPDRFSGSGSGTDFTLRISRVEADVGVYYCMQHLEYPVTFGAGTKVEIK

10

5D5A5 VH (SEQ ID No. 3)

QVQLQQSGAELAKPGASVKMSCKTSGYSFSSYWMHWVKQRPGQGLEWIGYINPS
TGYTENNQKFKDKVTLTADKSSNTAYMQLNSLTSEDSAVYYCARSGRLYFDVWGA
GTTVTVSS

15

5D5A5 VL (SEQ ID No. 4)

DIVLTQSPPSLAVSLGQRATISCRASESIDLYGFTFMHWYQQKPGQPPKILYRASNL
ESGIPARFSGSGSRTDFTLTINPVEADDVATYYCQQTCHEDPYTFGGGKLEIK

20 The antigen-binding domain of the first CAR may comprise the 6 CDRs from 5D5A5 and the antigen-binding domain of the second CAR may comprise the 6 CDRs from 5D3D11.

25 The antigen-binding domain of the first CAR may comprise the VH and/or VL domain(s) from 5D5A5 or a variant thereof; and the antigen-binding domain of the second CAR may comprise the VH and/or VL domain(s) from 5D3D11 or a variant thereof. Variant VH and VL domains may have at least 80, 90, 95 or 99% identity to the sequences given above, provided that they retain PSA-binding activity.

30 CARCINOEMBRYONIC ANTIGEN (CEA)

The soluble ligand may be CEA.

35 Carcinoembryonic antigen (CEA) describes a set of highly related glycoproteins involved in cell adhesion. CEA is normally produced in gastrointestinal tissue during fetal development, but the production stops before birth. Therefore CEA is usually present only at very low levels in the blood of healthy adults. However, the serum

levels are raised in some types of cancer, which means that it can be used as a tumor marker in clinical tests.

CEA are glycosyl phosphatidyl inositol (GPI) cell surface anchored glycoproteins whose specialized sialofucosylated glycoforms serve as functional colon carcinoma L-selectin and E-selectin ligands, which may be critical to the metastatic dissemination of colon carcinoma cells. Immunologically they are characterized as members of the CD66 cluster of differentiation.

CEA and related genes make up the CEA family belonging to the immunoglobulin superfamily. In humans, the carcinoembryonic antigen family consists of 29 genes, 10 18 of which are normally expressed. The following is a list of human genes which encode carcinoembryonic antigen-related cell adhesion proteins: CEACAM1, CEACAM3, CEACAM4, CEACAM5, CEACAM6, CEACAM7, CEACAM8, CEACAM16, CEACAM18, CEACAM19, CEACAM20, CEACAM21

15 Various antibodies which target CEA are described in WO 2011/034660.

VASCULAR ENDOTHELIAL GROWTH FACTOR (VEGF)

The soluble ligand may be VEGF.

20 Vascular endothelial growth factor (VEGF) is a signal protein produced by cells that stimulates vasculogenesis and angiogenesis. It is part of the system that restores the oxygen supply to tissues when blood circulation is inadequate. Serum concentration of VEGF is high in bronchial asthma and diabetes mellitus. VEGF's normal function 25 is to create new blood vessels during embryonic development, new blood vessels after injury, muscle following exercise, and new vessels (collateral circulation) to bypass blocked vessels.

When VEGF is overexpressed, it can contribute to disease. Solid cancers cannot 30 grow beyond a limited size without an adequate blood supply; cancers that can express VEGF are able to grow and metastasize.

VEGF is a sub-family of the platelet-derived growth factor family of cystine-knot 35 growth factors. They are important signaling proteins involved in both vasculogenesis (the de novo formation of the embryonic circulatory system) and angiogenesis (the growth of blood vessels from pre-existing vasculature).

The VEGF family comprises in mammals five members: VEGF-A, placenta growth factor (PGF), VEGF-B, VEGF-C and VEGF-D.

Various antibodies to VEGF are known, such as bevacizumab (Avastin) and 5 Ranibizumab (Lucentis).

MEMBRANE BOUND LIGANDS

The term "membrane-bound ligand" is used to indicate a ligand or antigen which is 10 part of or attached to a cell. The ligand may be expressed at the surface of a target cell. The ligand may, for example be a transmembrane protein.

The antigen binding domain may bind a TAA which is expressed on a cell, for example a cancer cell, at a low density. A TAA expressed at low density may refer, 15 for example, to a TAA expressed at a level of 10s to 1000s molecules per cell.

Examples of TAAs which are known to be expressed at low densities in certain cancers include, but are not limited to, ROR1 in CLL, Typr-1 in melanoma and BCMA in myeloma.

20 Antigen-binding domains (such as scFvs or mAbs) which bind these TAAs have previously been described, for example as shown in the following Table 1.

Table 1

25

Tumour-associated antigen	Antigen-binding domain	Reference
ROR-1	2A2, 2D11	S. Baskar et al., Landes Bioscience, vol. 4, (3) 349–361), R12, R11, Y31 (J. Yang et al., PLOSone, vol. 6, (6), e21018, 2011
Typr-1	TA99	P. Boross et al., Immunology Letters, vol. 160, (2), 151-157, 2014
BCMA	C12A3.2 and C11D5.3	R. Carpenter et al., Clin Cancer Res., vol. 19, (8)

		2048–2060, 2013), J6M0 (Y. Tai et al., Blood, vol 123, (20), 3128-3138, 2014
--	--	---

SPACER

5 The CARs of the present invention may comprise a spacer sequence to connect the antigen-binding domain with the transmembrane domain and spatially separate the antigen-binding domain from the endodomain. A flexible spacer allows to the antigen-binding domain to orient in different directions to enable antigen binding.

10 The spacer of the first CAR may be different from the spacer of the second CAR.

The spacer sequence may, for example, comprise an IgG1 Fc region, an IgG1 hinge or a CD8 stalk. The linker may alternatively comprise an alternative linker sequence which has similar length and/or domain spacing properties as an IgG1 Fc region, an IgG1 hinge or a CD8 stalk.

A human IgG1 spacer may be altered to remove Fc binding motifs.

Examples of amino acid sequences for these spacers are given below:

20 SEQ ID No. 5 (hinge-CH₂CH₃ of human IgG1)
AEPKSPDKTHTCPPCPAPPVAGPSVFLFPPKPKDTLMIAARTPEVTCVVVDVSHEDPE
VKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKA
LPAPIEKTIISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESN
25 GQPENNYKTPPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQK
SLSLSPGKKD

SEQ ID No. 6(human CD8 stalk):

TTTPAPRPPPTPAPTIASQPLSLRPEACRPAAGGAHVTRGLDFACDI

30 SEQ ID No. 7 (human IgG1 hinge):
AEPKSPDKTHTCPPCPKDPK

COILED COIL DOMAIN

The first and/or second CAR of cell of the present invention may comprise a coiled coil spacer domain.

5

A coiled coil is a structural motif in which two to seven alpha-helices are wrapped together like the strands of a rope (Figure 6). Many endogenous proteins incorporate coiled coil domains. The coiled coil domain may be involved in protein folding (e.g. it interacts with several alpha helical motifs within the same protein chain) or 10 responsible for protein-protein interaction. In the latter case, the coiled coil can initiate homo or hetero oligomer structures.

10

As used herein, the terms 'multimer' and 'multimerization' are synonymous and interchangeable with 'oligomer' and 'oligomerization'.

15

The structure of coiled coil domains is well known in the art. For example as described by Lupas & Gruber (Advances in Protein Chemistry; 2007; 70; 37-38).

20

Coiled coils usually contain a repeated pattern, hxxhcxc, of hydrophobic (h) and charged (c) amino-acid residues, referred to as a heptad repeat. The positions in the heptad repeat are usually labeled abcdefg, where a and d are the hydrophobic positions, often being occupied by isoleucine, leucine, or valine. Folding a sequence with this repeating pattern into an alpha-helical secondary structure causes the hydrophobic residues to be presented as a 'stripe' that coils gently around the helix in left-handed fashion, forming an amphipathic structure. The most favourable way for 25 two such helices to arrange themselves in the cytoplasm is to wrap the hydrophobic strands against each other sandwiched between the hydrophilic amino acids. Thus, it is the burial of hydrophobic surfaces that provides the thermodynamic driving force for the oligomerization. The packing in a coiled-coil interface is exceptionally tight, with 30 almost complete van der Waals contact between the side-chains of the a and d residues.

30

35

The α -helices may be parallel or anti-parallel, and usually adopt a left-handed super-coil. Although disfavoured, a few right-handed coiled coils have also been observed in nature and in designed proteins

The coiled coil domain may be any coiled coil domain which is capable of forming a coiled coil multimer such that a complex of CARs comprising the coiled coil domain is formed.

5 The relationship between the sequence and the final folded structure of a coiled coil domain are well understood in the art (Mahrenholz *et al*; Molecular & Cellular Proteomics; 2011; 10(5):M110.004994). As such the coiled coil domain may be a synthetically generated coiled coil domain.

10 Examples of proteins which contain a coiled coil domain include, but are not limited to, kinesin motor protein, hepatitis D delta antigen, archaeal box C/D sRNP core protein, cartilage-oligomeric matrix protein (COMP), mannose-binding protein A, coiled-coil serine-rich protein 1, polypeptide release factor 2, SNAP-25, SNARE, Lac repressor or apolipoprotein E.

15

The sequence of various coiled coil domains is shown below:

Kinesin motor protein: parallel homodimer (SEQ ID No. 8)

MHAALSTEVVHLRQRTEELLRCNEQQAAELETCKEQLFQSNMERKELHNTVMDLR

20 GN

Hepatitis D delta antigen: parallel homodimer (SEQ ID No. 9)

GREDILEQWVSGRKKLEELERDLRKLKKIKKLEEDNPWLGNIKGIIGKY

25 Archaeal box C/D sRNP core protein: anti-parallel heterodimer (SEQ ID No. 10)

RYVVALVKALEEIDESINMLNEKLEDIRAVKESEITEKFEKKIRELRELRRDVEREIEEV
M

Mannose-binding protein A: parallel homotrimer (SEQ ID No. 11)

30 AIEVKLANMEAEINTLKSKELTNKLHAFSM

Coiled-coil serine-rich protein 1: parallel homotrimer (SEQ ID No. 12)

EWEALEKKLAALESKLQALEKKLEALEHG

35 Polypeptide release factor 2: anti-parallel heterotrimer

Chain A: INPVNNRIQDLTERSDVLRGYLDY (SEQ ID No. 13)

Chain B:

VVDTLDQMKQGLEDVSGLLELAVEADDEETFNEAVAEELDALEEKLAQLEFR (SEQ ID No. 14)

5 SNAP-25 and SNARE: parallel heterotetramer

Chain A: IETRHSEIILKLENSIRELHDMFMDMAMLVESQGEMIDRIEYNVEHAVDYVE (SEQ ID No. 15)

Chain B:

ALSEIETRHSEIILKLENSIRELHDMFMDMAMLVESQGEMIDRIEYNVEHAVDYVERA

10 VSDTKKAVKY (SEQ ID No. 16)

Chain C:

ELEEMQRRAADQLADESLESTRMLQLVEESKDAGIRTLVMLDEQGEQLERIEE

GMDQINKDMKEAEKNL (SEQ ID No. 17)

15 Chain D: IETRHSEIILKLENSIRELHDMFMDMAMLVESQGEMIDRIEYNVEHAVDYVE (SEQ ID No. 18)

Lac repressor: parallel homotetramer

SPRALADSLMQLARQVSRL (SEQ ID No. 19)

20 Apolipoprotein E: anti-parallel heterotetramer

SGQRWELALGRFWDYLRLWQTLSEQVQEELLSSQVTQELRALMDETMKELKAYKS
ELEEQLTARLSKELQAAQARLGADMEDVCGRLVQYRGEVQAMLGQSTEELRVRLA
SHLRKLRKRLRDADDLQKRLAVYQA (SEQ ID No. 20)

25 A coiled coil domain is capable of oligomerization. The coiled coil domain may be capable of forming a dimer, a trimer, a tetramer, a pentamer, a hexamer or a heptamer.

30 Examples of coiled coil domains which are capable of forming multimers comprising more than two coiled coil domains include, but are not limited to, those from cartilage-oligomeric matrix protein (COMP), mannose-binding protein A, coiled-coil serine-rich protein 1, polypeptide release factor 2, SNAP-25, SNARE, Lac repressor or apolipoprotein E (see SEQ ID Nos. 11-20 above).

35 The coiled coil domain may be the COMP coiled coil domain.

COMP is one of the most stable protein complexes in nature (stable from 0°C-100°C and a wide range of pH) and can only be denatured with 4-6M guanidine hydrochloride. The COMP coiled coil domain is capable of forming a pentamer. COMP is also an endogenously expressed protein that is naturally expressed in the 5 extracellular space. This reduces the risk of immunogenicity compared to synthetic spacers. Furthermore, the crystal structure of the COMP coiled coil motif has been solved which gives an accurate estimation on the spacer length. The COMP structure is ~5.6nm in length (compared to the hinge and CH2CH3 domains from human IgG which is ~8.1nm).

10

The coiled coil domain may consist of or comprise the sequence shown as SEQ ID No. 21 or a fragment thereof.

SEQ ID No. 21

15 DLGPQMLRELQETNAALQDVRELLRQQVREITFLKNTVMECDACG

It is possible to truncate the COMP coiled-coil domain at the N-terminus and retain surface expression. The coiled-coil domain may therefore comprise or consist of a truncated version of SEQ ID No. 21, which is truncated at the N-terminus. The 20 truncated COMP may comprise the 5 C-terminal amino acids of SEQ ID No. 21, i.e. the sequence CDACG. The truncated COMP may comprise 5 to 44 amino acids, for example, at least 5, 10, 15, 20, 25, 30, 35 or 40 amino acids. The truncated COMP may correspond to the C-terminus of SEQ ID No. 21. For example a truncated COMP comprising 20 amino acids may comprise the sequences 25 QQVREITFLKNTVMECDACG. Truncated COMP may retain the cysteine residue(s) involved in multimerisation. Truncated COMP may retain the capacity to form multimers.

30 Various coiled coil domains are known which form hexamers such as gp41derived from HIV, and an artificial protein designed hexamer coiled coil described by N. Zaccai et al. (2011) *Nature Chem. Bio.*, (7) 935-941). A mutant form of the GCN4-p1 leucine zipper forms a heptameric coiled-coil structure (J. Liu. et al., (2006) *PNAS* (103) 15457-15462).

35 The coiled coil domain may comprise a variant of one of the coiled coil domains described above, providing that the variant sequence retains the capacity to form a coiled coil oligomer. For example, the coiled coil domain may comprise a variant of

the sequence shown as SEQ ID No. 8 to 21 having at least 80, 85, 90, 95, 98 or 99% sequence identity, providing that the variant sequence retains the capacity to form a coiled coil oligomer.

5 The percentage identity between two polypeptide sequences may be readily determined by programs such as BLAST which is freely available at <http://blast.ncbi.nlm.nih.gov>.

TRANSMEMBRANE DOMAIN

10 The transmembrane domain is the sequence of a CAR that spans the membrane. It may comprise a hydrophobic alpha helix. The transmembrane domain may be derived from CD28, which gives good receptor stability.

15 SIGNAL PEPTIDE

The CARs of the present invention may comprise a signal peptide so that when they are expressed in a cell, such as a T-cell, the nascent protein is directed to the endoplasmic reticulum and subsequently to the cell surface, where it is expressed.

20 The core of the signal peptide may contain a long stretch of hydrophobic amino acids that has a tendency to form a single alpha-helix. The signal peptide may begin with a short positively charged stretch of amino acids, which helps to enforce proper topology of the polypeptide during translocation. At the end of the signal peptide 25 there is typically a stretch of amino acids that is recognized and cleaved by signal peptidase. Signal peptidase may cleave either during or after completion of translocation to generate a free signal peptide and a mature protein. The free signal peptides are then digested by specific proteases.

30 The signal peptide may be at the amino terminus of the molecule.

The signal peptide may comprise the sequence shown as SEQ ID No. 22, 23 or 24 or a variant thereof having 5, 4, 3, 2 or 1 amino acid mutations (insertions, substitutions or additions) provided that the signal peptide still functions to cause cell surface 35 expression of the CAR.

SEQ ID No. 22: MGTSLLCWMALCLLGADHADG

The signal peptide of SEQ ID No. 22 is compact and highly efficient and is derived from TCR beta chain. It is predicted to give about 95% cleavage after the terminal glycine, giving efficient removal by signal peptidase.

5

SEQ ID No. 23: MSLPVTALLPLALLLHAARP

The signal peptide of SEQ ID No. 23 is derived from IgG1.

10 SEQ ID No. 24: MAVPTQVLGLLLLWLTDARC

The signal peptide of SEQ ID No. 24 is derived from CD8a.

ENDODOMAIN

15

The endodomain is the portion of a classical CAR which is located on the intracellular side of the membrane.

20 The endodomain is the signal-transmission portion of a classical CAR. After antigen recognition by the antigen binding domain, individual CAR molecules cluster, native CD45 and CD148 are excluded from the synapse and a signal is transmitted to the cell.

25 The endodomain of the first, second or third CAR as defined herein may be or comprise an intracellular signalling domain. In an alternative embodiment, the endodomain of the present CAR may be capable of interacting with an intracellular signalling molecule which is present in the cytoplasm, leading to signalling.

30 The intracellular signalling domain or separate intracellular signalling molecule may be or comprise a T cell signalling domain.

35 The most commonly used signalling domain component is that of CD3-zeta endodomain, which contains 3 ITAMs. This transmits an activation signal to the T cell after antigen is bound. CD3-zeta may not provide a fully competent activation signal and additional co-stimulatory signalling may be needed. For example, chimeric CD28 and OX40 can be used with CD3-Zeta to transmit a proliferative / survival signal, or all three can be used together.

The present CAR may comprise the CD3-Zeta endodomain alone, the CD3-Zeta endodomain with that of either CD28 or OX40 or the CD28 endodomain and OX40 and CD3-Zeta endodomain.

5

The endodomain may comprise one or more of the following: an ICOS endodomain, a CD27 endodomain, a BTLA endodomain, a CD30 endodomain, a GITR endodomain and an HVEM endodomain.

10 The endodomain may comprise the sequence shown as SEQ ID No. 25 to 33 or a variant thereof having at least 80% sequence identity.

SEQ ID No. 25 - CD3 Z endodomain

15 RVKFSRSADAPAYQQGQNQLYNELNLGRREEYDVLKDRRGRDPEMGGKPRRKNP
QEGLYNELQKDKMAEAYSEIGMKGERRRGKGHDGLYQGLSTATKDTYDALHMQAL
PPR

SEQ ID No. 26 - CD28 and CD3 Zeta endodomains

20 SKRSRLLHSDYMNMTPRRPGPTRKHYQPYAPPRDFAAYRSRVKFSRSADAPAYQQ
GQNQLYNELNLGRREEYDVLKDRRGRDPEMGGKPRRKNPQEGLYNELQKDKMAE
AYSEIGMKGERRRGKGHDGLYQGLSTATKDTYDALHMQALPPR

SEQ ID No. 27 - CD28, OX40 and CD3 Zeta endodomains

25 SKRSRLLHSDYMNMTPRRPGPTRKHYQPYAPPRDFAAYRSRDQRLPPDAHKPPG
GGSFRTPIQEEQADAHSTLAKIRVKFSRSADAPAYQQGQNQLYNELNLGRREEYDV
LDKRRGRDPEMGGKPRRKNPQEGLYNELQKDKMAEAYSEIGMKGERRRGKGHDG
LYQGLSTATKDTYDALHMQALPPR

SEQ ID No. 28 - ICOS endodomain

30 CWLTKKKYSSSVHDPNGEYMFMRNAVNTAKKSRLTDVTL

SEQ ID No. 29 - CD27 endodomain

QRRKYRSNKGESPVEPAEPCHYSCPREEEGSTIPIQEDYRKPEPACSP

35 SEQ ID No. 30 - BTLA endodomain

RRHQGKQNELSDTAGREINLVDAHLKSEQTEASTRQNSQVLLSETGIYDNDPDLCF
RMQEGSEVYSNPCLEENKPGIVYASLNHSVIGPNSRLARNVKEAPTEYASICVRS

SEQ ID No. 31 - CD30 endodomain

HRRACRKIRQKLHLCYPVQTSQPKLELVDSRPRRSSTQLRSGASVTEPVAEERGL

MSQPLMETCHSVGAAYLESLPLQDASPAGGPSSPRDLPEPRVSTEHTNNKIEKIYIM

5 KADTVIVGTVKAELPEGRGLAGPAEPELEEELEADHTPHYPEQETEPPLGSCSDVML
SVEEEGKEDPLPTAASGK

SEQ ID No. 32 - GITR endodomain

QLGLHIWQLRSQCMWPRETQLLEVPPSTEDARSCQFPEEERGERSAEEKGRLGD

10 LWV

SEQ ID No. 33 - HVEM endodomain

CVKRRKPRGDVVKVIVSVQRKRQEAEGEATVIEALQAPPDVTTVAVEETIPSFTGRS

PNH

15

A variant sequence may have at least 80%, 85%, 90%, 95%, 98% or 99% sequence identity to SEQ ID No. 25 to 33, provided that the sequence provides an effective intracellular signalling domain.

20 SUBSEQUENT CAR(S)

In addition to the first and second CARs defined above, the cell of the invention may comprise third and optionally subsequent CARs (fourth, fifth, sixth etc).

25 A third CAR may, for example, bind a cell surface antigen, such as a tumour associated antigen.

Various tumour associated antigens (TAA) are known, as shown in the following Table 2. The antigen-binding domain of the third or subsequent CAR may be a 30 domain which is capable of binding one of these TAAs.

Table 2

Cancer type	TAA
Diffuse Large B-cell Lymphoma	CD19, CD20, CD22
Breast cancer	ErbB2, MUC1
AML	CD13, CD33

Neuroblastoma	GD2, NCAM, ALK, GD2
B-CLL	CD19, CD52, CD160
Colorectal cancer	Folate binding protein, CA-125
Chronic Lymphocytic Leukaemia	CD5, CD19
Glioma	EGFR, Vimentin
Multiple myeloma	BCMA, CD138
Renal Cell Carcinoma	Carbonic anhydrase IX, G250
Prostate cancer	PSMA
Bowel cancer	A33

NUCLEIC ACID

The present invention further provides a nucleic acid construct which comprises a first nucleic acid sequence encoding a first CAR as defined in connection with the first aspect of the invention; and a second nucleic acid sequence encoding a second CAR as defined in connection with the first aspect of the invention.

The nucleic acid construct may have the following structure:

10

AgB1-spacer1-TM1-endo1-coexpr-AbB2-spacer2-TM2-endo2

in which

AgB1 is a nucleic acid sequence encoding the antigen-binding domain of the first CAR;

spacer 1 is a nucleic acid sequence encoding the spacer of the first CAR;

TM1 is a nucleic acid sequence encoding the transmembrane domain of the first CAR;

endo 1 is a nucleic acid sequence encoding the endodomain of the first CAR;

20 coexpr is a nucleic acid sequence enabling co-expression of both CARs

AgB2 is a nucleic acid sequence encoding the antigen-binding domain of the second CAR;

spacer 2 is a nucleic acid sequence encoding the spacer of the second CAR;

TM2 is a nucleic acid sequence encoding the transmembrane domain of the second CAR;

25 CAR;

endo 2 is a nucleic acid sequence encoding the endodomain of the second CAR.

When the nucleic acid construct is expressed in a cell, such as a T-cell, it encodes a polypeptide which is cleaved at the cleavage site such that the first and second CARs are co-expressed at the cell surface.

5 Where the nucleic acid construct encodes three CARs, it may have the structure:

AgB1-spacer1-TM1-endo1-coexpr1-AbB2-spacer2-TM2-endo2-coexpr2-AbB3-spacer3-TM3-endo3

10 The endodomain may be an intracellular cell signalling domain or may associate intracellularly with a separate cell signalling domain.

As used herein, the terms “polynucleotide”, “nucleotide”, and “nucleic acid” are intended to be synonymous with each other.

15

It will be understood by a skilled person that numerous different polynucleotides and nucleic acids can encode the same polypeptide as a result of the degeneracy of the genetic code. In addition, it is to be understood that skilled persons may, using routine techniques, make nucleotide substitutions that do not affect the polypeptide sequence 20 encoded by the polynucleotides described here to reflect the codon usage of any particular host organism in which the polypeptides are to be expressed.

Nucleic acids according to the invention may comprise DNA or RNA. They may be single-stranded or double-stranded. They may also be polynucleotides which include 25 within them synthetic or modified nucleotides. A number of different types of modification to oligonucleotides are known in the art. These include methylphosphonate and phosphorothioate backbones, addition of acridine or polylysine chains at the 3' and/or 5' ends of the molecule. For the purposes of the use as described herein, it is to be understood that the polynucleotides may be 30 modified by any method available in the art. Such modifications may be carried out in order to enhance the in vivo activity or life span of polynucleotides of interest.

The terms “variant”, “homologue” or “derivative” in relation to a nucleotide sequence include any substitution of, variation of, modification of, replacement of, deletion of or 35 addition of one (or more) nucleic acid from or to the sequence.

In the structure above, "coexpr" is a nucleic acid sequence enabling co-expression of both first and second CARs. It may be a sequence encoding a cleavage site, such that the nucleic acid construct produces comprises two or more CARs joined by a cleavage site(s). The cleavage site may be self-cleaving, such that when the 5 polypeptide is produced, it is immediately cleaved into individual peptides without the need for any external cleavage activity.

The cleavage site may be any sequence which enables the first and second CARs to become separated.

10

The term "cleavage" is used herein for convenience, but the cleavage site may cause the peptides to separate into individual entities by a mechanism other than classical cleavage. For example, for the Foot-and-Mouth disease virus (FMDV) 2A self-cleaving peptide (see below), various models have been proposed for to account for the 15 "cleavage" activity: proteolysis by a host-cell proteinase, autoproteolysis or a translational effect (Donnelly et al (2001) J. Gen. Virol. 82:1027-1041). The exact mechanism of such "cleavage" is not important for the purposes of the present invention, as long as the cleavage site, when positioned between nucleic acid sequences which encode proteins, causes the proteins to be expressed as separate 20 entities.

The cleavage site may be a furin cleavage site.

Furin is an enzyme which belongs to the subtilisin-like proprotein convertase family. 25 The members of this family are proprotein convertases that process latent precursor proteins into their biologically active products. Furin is a calcium-dependent serine endoprotease that can efficiently cleave precursor proteins at their paired basic amino acid processing sites. Examples of furin substrates include proparathyroid hormone, transforming growth factor beta 1 precursor, proalbumin, pro-beta-secretase, 30 membrane type-1 matrix metalloproteinase, beta subunit of pro-nerve growth factor and von Willebrand factor. Furin cleaves proteins just downstream of a basic amino acid target sequence (canonically, Arg-X-(Arg/Lys)-Arg') and is enriched in the Golgi apparatus.

35 The cleavage site may be a Tobacco Etch Virus (TEV) cleavage site.

TEV protease is a highly sequence-specific cysteine protease which is chymotrypsin-like proteases. It is very specific for its target cleavage site and is therefore frequently used for the controlled cleavage of fusion proteins both *in vitro* and *in vivo*. The consensus TEV cleavage site is ENLYFQ\S (where ‘\’ denotes the cleaved peptide bond). Mammalian cells, such as human cells, do not express TEV protease. Thus in embodiments in which the present nucleic acid construct comprises a TEV cleavage site and is expressed in a mammalian cell – exogenous TEV protease must also be expressed in the mammalian cell.

10 The cleavage site may encode a self-cleaving peptide.

A ‘self-cleaving peptide’ refers to a peptide which functions such that when the polypeptide comprising the proteins and the self-cleaving peptide is produced, it is immediately “cleaved” or separated into distinct and discrete first and second 15 polypeptides without the need for any external cleavage activity.

The self-cleaving peptide may be a 2A self-cleaving peptide from an aphtho- or a cardiovirus. The primary 2A/2B cleavage of the aphtho- and cardioviruses is mediated by 2A “cleaving” at its own C-terminus. In aphthoviruses, such as foot-and-mouth 20 disease viruses (FMDV) and equine rhinitis A virus, the 2A region is a short section of about 18 amino acids, which, together with the N-terminal residue of protein 2B (a conserved proline residue) represents an autonomous element capable of mediating “cleavage” at its own C-terminus (Donnelly et al (2001) as above).

25 “2A-like” sequences have been found in picornaviruses other than aphtho- or cardioviruses, ‘picornavirus-like’ insect viruses, type C rotaviruses and repeated sequences within Trypanosoma spp and a bacterial sequence (Donnelly et al (2001) as above). The cleavage site may comprise one of these 2A-like sequences, such as:

30 YHADYYKQRLIHDVEMNPGP (SEQ ID No. 34)
HYAGYFADLLIHDIETNPGP (SEQ ID No. 35)
QCTNYALLKLAGDVESNPGP (SEQ ID No. 36)
ATNFSLLKQAGDVEENPGP (SEQ ID No. 37)
35 AARQMLLLLSGDVETNPGP (SEQ ID No. 38)
RAEGRGSSLTCGDVEENPGP (SEQ ID No. 39)
TRAIEIEDELIRAGIESNPGP (SEQ ID No. 40)

TRAIEIEDELIRADIESNPGP (SEQ ID No. 41)
AKFQIDKILISGDVELNPGP (SEQ ID No. 42)
SSIIRTKMLVSGDVEENPGP (SEQ ID No. 43)
CDAQRQKLLSGDIEQNPGP (SEQ ID No. 44)
5 YPIDFGGFLVKADSEFNPGP (SEQ ID No. 45)

The cleavage site may comprise the 2A-like sequence shown as SEQ ID No. 39 (RAEGRGSLLTCGDVEENPGP).

10 The present invention also provides a kit comprising one or more nucleic acid sequence(s) encoding first and second CARs according to the first aspect of the present invention.

SPLIT CAR SYSTEMS

15 In one embodiment of the invention, the T-cell stimulating endodomains are "split" between the first and second CARs recognising a soluble ligand, and the third CAR recognising a cell-surface antigen (see Figure 9).

20 An advantage of such a split-CAR system is that it avoids the possibility of the T-cell "shadow-boxing" i.e. trying to kill something that isn't there. This may occur if, for example, the soluble ligand is present in the vicinity of the T cell, but the tumour cell which secreted the soluble ligand is too far away to be killed by an activated T cell.

25 In this system, the endodomains may, for example, be split between the first and/or second CAR which bind the soluble ligand; and the third CAR which binds with cell-surface antigen, as shown in the following Table:

Endodomain(s) on first and/or second CAR	Endodomain(s) on third CAR
CD28-OX40 or CD28-41BB	CD3 zeta
OX40 or 41BB	CD28-CD3 zeta

30 In this embodiment of the invention the endodomains of the third CAR and the first and/or second CAR(s) are "complementary" in the sense that together, they provide signals 1 and 2 or 1, 2 and 3, leading to cell activation. Optimal T cell activation

therefore occurs when the soluble ligand is bound by the first and second CARs and the cell surface antigen is bound by the third CAR.

5 In this embodiment, the third CAR may bind prostate-specific membrane antigen (PSMA) and the first and second CARs may bind prostate-specific antigen (PSA).

AGGREGATION-BASED INHIBITORY CAR SYSTEM

10 In a second embodiment of the invention, ligation of the ligand by the first and second CAR causes inhibition of the third CAR. Binding the cell surface antigen by the third CAR in the absence of ligand (eg soluble ligand) leads to cell activation. By contrast, binding the cell surface antigen by the third CAR in the presence of ligand (eg soluble ligand) does not lead to cell activation, or leads to reduced cell activation (See Figure 10).

15 In this embodiment the soluble ligand may be an entity, such as a cytokine, which is released by normal tissue but not by cancerous tissue. The ligand may, for example, be IL-6. In this way, the inhibitory signal provided by the soluble CAR could be used to provide a negative feedback loop for CAR-associated problems such as cytokine 20 release syndrome or mass-activation syndrome.

The first and/or second CAR comprise(s) a “ligation-on” inhibitory endodomain, such that when the first and second CARs bind the ligand, cell activation caused by the third CAR binding the cell surface antigen is inhibited.

25 The “ligation-on” inhibitory endodomain does not significantly inhibit T-cell activation by the third CAR in the absence of the soluble ligand, but inhibits T-cell activation by the third CAR when the first and second CARs bind the soluble ligand.

30 The “ligation-on” inhibitory endodomain may be or comprise a tyrosine phosphatase with a sufficiently slow catalytic rate for phosphorylated ITAMs that does not inhibit TCR signalling when only the third CAR binds its (cell surface) antigen, but it is capable of inhibiting the TCR signalling response when aggregation of the first and second CARs cause the inhibitory endodomains to be concentrated at the synapse.

35 The inhibitory endodomain may comprise all or part of a protein-tyrosine phosphatase such as PTPN6.

Protein tyrosine phosphatases (PTPs) are signaling molecules that regulate a variety of cellular processes including cell growth, differentiation, mitotic cycle, and oncogenic transformation. The N-terminal part of this PTP contains two tandem Src homolog (SH2) domains, which act as protein phospho-tyrosine binding domains, and mediate the interaction of this PTP with its substrates. This PTP is expressed primarily in hematopoietic cells, and functions as an important regulator of multiple signaling pathways in hematopoietic cells.

10 The inhibitor domain may comprise all of PTPN6 (SEQ ID No. 46) or just the phosphatase domain (SEQ ID No. 47).

SEQ ID 46 – sequence of PTPN6

MVRWFHRDLSGLDAETLLKGRGVHGSFLARPSRKNQGDFSLSRVGDQVTHIRIQN
15 SGDFYDLYGGEKFATLTELVEYYTQQQGVLQDRGTIIHLKYPLNCSDPTSERWYH
GHMSGGQAETLLQAKGEPTFLVRESLSQPGDFVLSVLSQPKAGPGSPLRVTHIK
VMCEGGGRYTVGGLETDSLTDLVEHFKKTGIEEASGAFVYLRQPYYATRVNAADIE
RVLELNKKQESEDTAKAGFWEEFESLQKQEVKNLHQRLEGQRPENKGKNRYKNILP
FDHSRVLQGRDSNIPGSDYINANYIKNQLLGPDENAKTYIASQGCLEATVNDFWQM
20 AWQENSERVIVMTTREVEKGRNKCPYWPVEGMQRAYGPYSVTNCGEHDTTEYKL
RTLQVSPLDNGDLIREIWHYQYLSWPDHGPSEPGGVLSFLDQINQRQESLPHAGPI
IVHCSAGIGRTGTIIVIDMLMENISTKGLCDCIDIQKTIQMVRARSGMVQTEAQYKFIY
VAIAQFIETTKKKLEVLQSQKGQESEYGNITYPPAMKNAHAKASRTSSKHEDVYEN
LHTKNKREEKVKKQRSADKEKSKGSLKRK

25

SEQ ID 47 – sequence of phosphatase domain of PTPN6

FWEEFESLQKQEVKNLHQRLEGQRPENKGKNRYKNILPDFHSRVLQGRDSNIPGS
DYINANYIKNQLLGPDENAKTYIASQGCLEATVNDFWQMAWQENSERVIVMTTREVE
KGRNKCPYWPVEGMQRAYGPYSVTNCGEHDTTEYKLRTLQVSPLDNGDLIREIW
30 HYQYLSWPDHGPSEPGGVLSFLDQINQRQESLPHAGPIIVHCSAGIGRTGTIIVIDM
LMENISTKGLCDCIDIQKTIQMVRARSGMVQTEAQYKFIYVAIAQF

35 Alternatively the inhibitory endodomain may be an ITIM (Immunoreceptor Tyrosine-based Inhibition motif) containing endodomain such as that from CD22, LAIR-1, the Killer inhibitory receptor family (KIR), LILRB1, CTLA4, PD-1, BTLA etc. When phosphorylated, ITIMs recruits endogenous PTPN6 through its SH2 domain. If co-

localised with an ITAM containing endodomain, dephosphorylation occurs and the activating CAR is inhibited.

An ITIM is a conserved sequence of amino acids (S/I/V/LxYxxI/V/L) that is found in 5 the cytoplasmic tails of many inhibitory receptors of the immune system. One skilled in the art can easily find protein domains containing an ITIM. A list of human candidate ITIM-containing proteins has been generated by proteome-wide scans (Staub, et al (2004) *Cell. Signal.* 16, 435–456). Further, since the consensus sequence is well known and little secondary structure appears to be required, one 10 skilled in the art could generate an artificial ITIM.

ITIM endodomains from PDCD1, BTLA4, LILRB1, LAIR1, CTLA4, KIR2DL1, KIR2DL4, KIR2DL5, KIR3DL1 and KIR3DL3 are shown in SEQ ID 48 to 57 respectively

15 SEQ ID No. 48 - PDCD1 endodomain

CSRAARGTIGARRTGQPLKEDPSAVPVFSVDYGELDFQWREKTPEPPVPCVPEQT

EYATI

VFPSGMGTSSPARRGSADGPRSAQPLRPEDGHCSWPL

20 SEQ ID No. 49 - BTLA4

KLQRRWKRTQSQQGLQENSSGQSFFVRNKKVRRAPLSEGPHSLGCYNPMMEDGI

SYTTLRFPEMNIPRTGDAESSEMQRPPPDCDDTVTYSALHKRQVGDYENVIPDFPE

DEGIHYSELI

25 QFGVGERPQAQENVVDYVILKH

SEQ ID No. 50 - LILRB1

LRHRRQGKHWSTQRKADFQHPAGAVGPEPTDRGLQWRSSPAADAQEENLYAAV

KHTQPEDGVEDTRSPHDEDPQAVTYAEVKHSRPRREMASPPSPLSGEFLDTKDR

30 QAEEDRQMDTEAAASEAPQDVTYAQLHSRTLREATEPPPSQEGPSPAVPSIYATL

AIH

SEQ ID No. 51 - LAIR1

HRQNQIKQGPPRSKDEEQKPQQRPDLAVDVLERTADKATVNGLPEKDRRETDTSLA

35 AGSS

QEVTYAQLDHWALTQRTARAVSPQSTKPMAESITYAAVARH

SEQ ID No. 52 CTLA4

FLLWILAAVSSGLFFYSFLLTAVSLSKMLKKRSPLTTGVYVKMPPTEPECEKQFQPYF
IPIN

5 SEQ ID No. 53 KIR2DL1

GNSRHLHLIGTSVVIIPFAILLFFLLHRWCANKNAVMDQEPAGNRTVNREDSDE
QDP
QEVTYTQLNHCVFTQRKITRPSQRPKTPPTDIIVYTELPNAESRSKVVSCP

10 SEQ ID No. 54 KIR2DL4

GIARHLHAVIRYSVAILFTILPFFLLHRWCSKKKENAAVMNQEPAHGRTVNREDSDE
QDPQEVTYAQLDHICIFTQRKITGPSQRSPKTPSTDTSVCIELPNAEPRALSPAHEHHS
QALMGSSRETTALSQTQLASSNVPAAGI

15 SEQ ID No. 55 KIR2DL5

TGIRRHLHLIGTSVAILFIILFFFLLHCCCSNKKNAAVMDQEPAGDRTVNREDSDDQ
DPQEVTYAQLDHCVFTQTKITSPSQRPKTPPTDTTMYMELPNAKPRSLSPAHKHHS
QALRGSSRETTALSQNRVASSHVPAAGI

20 SEQ ID No. 56 KIR3DL1

KDPRHLHLIGTSVVIILFILLFFFLLHLWCSNKKNAAVMDQEPAGNRTANSEDSDEQD
PEEVTYAQLDHCVFTQRKITRPSQRPKTPPTDTILYTELPNAKPRSKVVSCP

SEQ ID No. 57 KIR3DL3

25 KDPGNSRHLHLIGTSVVIIPFAILLFFLLHRWCANKNAVMDQEPAGNRTVNREDS
DEQDPQEVTYAQQLNHCVFTQRKITRPSQRPKTPPTDTSV

Alternatively the inhibitory endodomain may be an ITIM containing endodomain co-expressed with a fusion protein. The fusion protein may comprise at least part of a protein-tyrosine phosphatase and at least part of a receptor-like tyrosine phosphatase. The fusion may comprise one or more SH2 domains from the protein-tyrosine phosphatase. For example, the fusion may be between a PTPN6 SH2 domain and CD45 endodomain or between a PTPN6 SH2 domain and CD148 endodomain. When phosphorylated, the ITIM domains recruit the fusion protein bring the highly potent CD45 or CD148 phosphatase to proximity to the activating endodomain blocking activation. The sequences of illustrative fusion proteins are given as SEQ ID No. 58 and 59.

SEQ ID No. 58 - PTPN6-CD45 fusion protein

WYHGHMSGQAETLLQAKGEPWTFLVRESLSQPGDFVLSVLSDQPKAGPGSPLRV
THIKVMCEGGRTVGGLETFDSLTDLVEHFKKTGIEEASGAFVYLRQPYKIYDLHKK

5 RSCNLDEQQELVERDDEKQLMNVEPIHADILLETYKRKIADEGRLFLAEFQSIPRVFS
KFPIKEARKP FNQNKNRYVDILPYDYNRVELSEINGDAGSNYINASYIDGFKEPRKYIA
AQGPRDETVDVFWRMIWEQKATVIVMVTCEEGNRNKCAEYWPSMEEGTRAFGD
VVVKINQHKRCPDYIIQKLNIVNKKEKATGREVTHIQFTSWPDHGVPEDPHLLLKLRR
RVNAFSNFFSGPIVVHCSAGVGRGTGYIGIDAMLEGLEAENKVVDVYGYVVKLRRQR
10 CLMVQVEAQYILIHQALVEYNQFGETEVNLSELHPYLHNMKRDPPEPSPLEAEFQ
RLPSYRSWRTQHIGNQEENKSKNRNSNVIPYDYNRVLKHELEMSKESEHDSDESSD
DDSDSEEPSKYINASFIMSYWKPEVMIAAQGPLKETIGDFMIQRKVKVIVMLTELKG
DQEICAQYWGEVKQTYGDIEVDLKDTDKSSTYTLRVFELRHSKRKDSRTVYQYQYT
NWSVEQLPAEPKELISMIVVVKQKLPQKNSSEGKHHKSTPLLIHCRDGSQQTGIFC
15 ALLNLLESAETEEVVDIFQVVVKALRKARPGMVSTFEQYQFLYDVIASTYPAQNGQVK
KNNHQEDKIEFDNEVDKVQDANCVNPLGAPEKLPEAKEQAEGSEPTSGTEGPEH
SVNGPASPALNQGS

SEQ ID No. 59 - PTPN6-CD148 fusion

20 ETLLQAKGEPWTFLVRESLSQPGDFVLSVLSDQPKAGPGSPLRVTHIKVMCEGGRT
TVGGLETFDSLTDLVEHFKKTGIEEASGAFVYLRQPYRKKRKDAKNNEVSFSQIKPK
KSKLIRVENFEAYFKQQQADSNCGFAEEYEDLKLVGISQPKYAAELAENRGKNRYNN
VLPYDISRVKLSVQTHSTDDYINANYMPGYHSKKDFIATQGPLPNTLKDFWRMVWE
KNVYAIIMLTKCVEQGRTKCEEYWPSKQAQDYGDITVAMTSEIVLPEWTIRDFTVKNI
25 QTSESHPLRQFHFTSWPDHGVPDTTDLLINFRYLVRDYMKQSPPESPILVHCSAGV
GRTGTFIAIDRLIYQIENENTDVYDLYDLMHRPLMVQTEDQYVFLNQCVL DIVRS
QKDSKVDLIYQNTTAMTIYENLAPVTTFGKTNGYIA

30 The inhibitory endodomain may comprise all or part of SEQ ID No 46 or 47. It may
comprise all or part of SEQ ID 48 to 57. It may comprise all or part of SEQ ID 48 to 57
co-expressed with either SEQ ID 58 or 59. It may comprise a variant of the sequence
or part thereof having at least 80% sequence identity, as long as the variant retains
the capacity to inhibit T cell signaling by the third CAR upon ligation of the first and
second CARs.

In a third embodiment of the invention the first CAR comprises two antigen binding domains: one which binds the soluble ligand; and one which binds a cell-surface antigen. This tandem arrangement of binding domains (TanCAR system) is illustrated schematically in Figure 11.

5

When the first CAR is expressed at the surface of a cell, such as a T-cell, the antigen binding-domain which binds the cell-surface antigen may be distal to the cell membrane and the antigen binding-domain which binds the soluble ligand may be proximal to the cell membrane

10

In this system, the second CAR may comprise an inhibitory endodomain, such that when the first and second CARs bind the soluble ligand, cell activation caused by the first CAR binding the cell surface antigen is inhibited.

15

The inhibitory endodomain is a “ligation-on” inhibitory endodomain, such that the second CAR does not significantly inhibit T-cell activation by the first CAR in the absence of soluble ligand, but inhibits T-cell activation by the first CAR when the first and second CAR bind the soluble ligand.

20

The inhibitory endodomain may be or comprise a phosphatase with slow kinetics, such as one comprising of the catalytic domain of PTPN6 or an ITIM as defined in the previous section.

In this embodiment of the invention, the first and second CAR may bind IL-6.

25

AGGREGATION-BASED AND GATE

30

In a fourth embodiment of the invention, the third CAR, which binds a cell-surface antigen, comprises an activating endodomain, and the first and/or second CAR(s) comprise(s) a “ligation-off” inhibitory endodomain (see Figure 12).

This embodiment is based on the kinetic segregation model (KS) of T-cell activation. This is a functional model, backed by experimental data, which explains how antigen recognition by a T-cell receptor is converted into down-stream activation signals.

35

Briefly: at the ground state, the signalling components on the T-cell membrane are in dynamic homeostasis whereby dephosphorylated ITAMs are favoured over phosphorylated ITAMs. This is due to greater activity of the transmembrane

CD45/CD148 phosphatases over membrane-tethered kinases such as lck. When a T-cell engages a target cell through a T-cell receptor (or CAR) recognition of cognate antigen, tight immunological synapses form. This close juxtapositioning of the T-cell and target membranes excludes CD45/CD148 due to their large ectodomains which 5 cannot fit into the synapse. Segregation of a high concentration of T-cell receptor associated ITAMs and kinases in the synapse, in the absence of phosphatases, leads to a state whereby phosphorylated ITAMs are favoured. ZAP70 recognizes a threshold of phosphorylated ITAMs and propagates a T-cell activation signal. This advanced understanding of T-cell activation is exploited by the present invention. In 10 particular, the invention is based on this understanding of how ectodomains of different length and/or bulk and/or charge and/or configuration and/or glycosylation result in differential segregation upon synapse formation.

In the aggregation-based AND gate of the invention embodiment, the third CAR which 15 binds the cell-surface antigen comprises an activating endodomain and the first and/or second CAR(s) which bind the soluble ligand comprise an inhibitory endodomain. The inhibitory CAR constitutively inhibits the third CAR, but upon binding the soluble ligand releases its inhibition of the activating CAR. In this manner, a T-cell can be engineered to trigger only in the presence of the cell-surface antigen 20 (Ligand A in Figure 12) and the soluble antigen (Ligand B in Figure 12). This behaviour is achieved by the third CAR comprising an activating endodomain containing ITAM domains for example the endodomain of CD3 Zeta, and the inhibitory CAR comprising the endodomain from a phosphatase able to dephosphorylate an ITAM (e.g. CD45 or CD148). When only the third CAR is ligated, 25 the first and/or second CAR with the inhibitory endodomain is in solution on the T-cell surface and can diffuse in and out of the synapse inhibiting the activating CAR. When the first and second CAR bind the soluble ligand, they aggregate causing segregation from the third CAR allowing the third CAR to trigger T-cell activation.

30 COLOCALISATION-BASED AND GATE

In a fifth embodiment of the invention, the first CAR comprises two antigen binding domains: one which binds the soluble ligand; and one which binds a cell-surface antigen. This tandem arrangement of binding domains (TanCAR system) is similar to 35 the thirs embodiment of the invention described above.

In this co-localisation-based AND gate, the first CAR lacks a functional endodomain. It may comprise an inert or truncated endodomain. The endodomain may lack any or a sufficient number of ITAMs to transmit an activation signal to the T cell after antigen is bound.

5

The second CAR comprises a functional endodomain which comprises one or more ITAMs capable of triggering T-cell signalling. Binding of the soluble ligand causes co-localisation of the first and second CARs and enables T-cell signalling to occur when the first CAR binds the cell surface antigen. The second CAR may, for example, comprise the CD3 zeta endodomain.

10

The second CAR may be monomeric to avoid signalling in the absence of Ligand A. This may be achieved by the second CAR comprising a monomeric spacer.

15 A truncated version of CD22 which comprises one or more Ig domains, may be used as a monomeric spacer.

VECTOR

20 The present invention also provides a vector, or kit of vectors, which comprises one or more nucleic acid sequence(s) encoding a first and a second CAR according to the first aspect of the invention. Such a vector may be used to introduce the nucleic acid sequence(s) into a host cell so that it expresses a first and a second CAR according to the first aspect of the invention.

25 The vector may, for example, be a plasmid or a viral vector, such as a retroviral vector or a lentiviral vector, or a transposon based vector or synthetic mRNA.

The vector may be capable of transfecting or transducing a T cell or a NK cell.

30 CELL

The present invention provides a cell which comprises a first chimeric antigen receptor (CAR) and a second CAR, the first and second CARs binding different epitopes on the same ligand.

35

The cell may comprise a nucleic acid or a vector of the present invention.

The cell may be a cytolytic immune cell such as a T cell or an NK cell.

5 T cells or T lymphocytes are a type of lymphocyte that play a central role in cell-mediated immunity. They can be distinguished from other lymphocytes, such as B cells and natural killer cells (NK cells), by the presence of a T-cell receptor (TCR) on the cell surface. There are various types of T cell, as summarised below.

10 Helper T helper cells (TH cells) assist other white blood cells in immunologic processes, including maturation of B cells into plasma cells and memory B cells, and activation of cytotoxic T cells and macrophages. TH cells express CD4 on their surface. TH cells become activated when they are presented with peptide antigens by MHC class II molecules on the surface of antigen presenting cells (APCs). These 15 cells can differentiate into one of several subtypes, including TH1, TH2, TH3, TH17, Th9, or TFH, which secrete different cytokines to facilitate different types of immune responses.

20 Cytolytic T cells (TC cells, or CTLs) destroy virally infected cells and tumor cells, and are also implicated in transplant rejection. CTLs express the CD8 at their surface. These cells recognize their targets by binding to antigen associated with MHC class I, which is present on the surface of all nucleated cells. Through IL-10, adenosine and other molecules secreted by regulatory T cells, the CD8+ cells can be inactivated to an anergic state, which prevent autoimmune diseases such as experimental 25 autoimmune encephalomyelitis.

30 Memory T cells are a subset of antigen-specific T cells that persist long-term after an infection has resolved. They quickly expand to large numbers of effector T cells upon re-exposure to their cognate antigen, thus providing the immune system with "memory" against past infections. Memory T cells comprise three subtypes: central memory T cells (TCM cells) and two types of effector memory T cells (TEM cells and TEMRA cells). Memory cells may be either CD4+ or CD8+. Memory T cells typically express the cell surface protein CD45RO.

35 Regulatory T cells (Treg cells), formerly known as suppressor T cells, are crucial for the maintenance of immunological tolerance. Their major role is to shut down T cell-mediated immunity toward the end of an immune reaction and to suppress auto-reactive T cells that escaped the process of negative selection in the thymus.

Two major classes of CD4+ Treg cells have been described — naturally occurring Treg cells and adaptive Treg cells.

Naturally occurring Treg cells (also known as CD4+CD25+FoxP3+ Treg cells) arise in the thymus and have been linked to interactions between developing T cells with both myeloid (CD11c+) and plasmacytoid (CD123+) dendritic cells that have been activated with TSLP. Naturally occurring Treg cells can be distinguished from other T cells by the presence of an intracellular molecule called FoxP3. Mutations of the FOXP3 gene can prevent regulatory T cell development, causing the fatal autoimmune disease IPEX.

Adaptive Treg cells (also known as Tr1 cells or Th3 cells) may originate during a normal immune response.

The cell may be a Natural Killer cell (or NK cell). NK cells form part of the innate immune system. NK cells provide rapid responses to innate signals from virally infected cells in an MHC independent manner

NK cells (belonging to the group of innate lymphoid cells) are defined as large granular lymphocytes (LGL) and constitute the third kind of cells differentiated from the common lymphoid progenitor generating B and T lymphocytes. NK cells are known to differentiate and mature in the bone marrow, lymph node, spleen, tonsils and thymus where they then enter into the circulation.

The CAR cells of the invention may be any of the cell types mentioned above.

T or NK cells according to the first aspect of the invention may either be created *ex vivo* either from a patient's own peripheral blood (1st party), or in the setting of a haematopoietic stem cell transplant from donor peripheral blood (2nd party), or peripheral blood from an unconnected donor (3rd party).

Alternatively, T or NK cells according to the first aspect of the invention may be derived from *ex vivo* differentiation of inducible progenitor cells or embryonic progenitor cells to T or NK cells. Alternatively, an immortalized T-cell line which retains its lytic function and could act as a therapeutic may be used.

In all these embodiments, CAR cells are generated by introducing DNA or RNA coding for first and second CARs by one of many means including transduction with a viral vector, transfection with DNA or RNA.

5 The CAR cell of the invention may be an *ex vivo* T or NK cell from a subject. The T or NK cell may be from a peripheral blood mononuclear cell (PBMC) sample. T or NK cells may be activated and/or expanded prior to being transduced with nucleic acid encoding the molecules providing the CAR according to the first aspect of the invention or a component(s) of the CAR signalling system according to the second
10 10 aspect of the invention, for example by treatment with an anti-CD3 monoclonal antibody.

The T or NK cell of the invention may be made by:

15 (i) isolation of a T or NK cell-containing sample from a subject or other sources listed above; and
(ii) transduction or transfection of the T or NK cells with one or more a nucleic acid sequence(s) encoding first and second CARs.

20 The T or NK cells may then be purified, for example, selected on the basis of expression of the antigen-binding domain of the antigen-binding polypeptide.

PHARMACEUTICAL COMPOSITION

25 The present invention also relates to a pharmaceutical composition containing a plurality of cells according to the first aspect of the invention.

30 The pharmaceutical composition may additionally comprise a pharmaceutically acceptable carrier, diluent or excipient. The pharmaceutical composition may optionally comprise one or more further pharmaceutically active polypeptides and/or compounds. Such a formulation may, for example, be in a form suitable for intravenous infusion.

METHOD OF TREATMENT

35 The present invention provides a method for treating and/or preventing a disease which comprises the step of administering the cells of the present invention (for example in a pharmaceutical composition as described above) to a subject.

5 A method for treating a disease relates to the therapeutic use of the cells of the present invention. Herein the cells may be administered to a subject having an existing disease or condition in order to lessen, reduce or improve at least one symptom associated with the disease and/or to slow down, reduce or block the progression of the disease.

10 The method for preventing a disease relates to the prophylactic use of the cells of the present invention. Herein such cells may be administered to a subject who has not yet contracted the disease and/or who is not showing any symptoms of the disease to prevent or impair the cause of the disease or to reduce or prevent development of at least one symptom associated with the disease. The subject may have a predisposition for, or be thought to be at risk of developing, the disease.

15 The method may involve the steps of:

- (i) isolating a T or NK cell-containing sample;
- (ii) transducing or transfecting such cells with a nucleic acid sequence or vector provided by the present invention;
- (iii) administering the cells from (ii) to a subject.

20 The T or NK cell-containing sample may be isolated from a subject or from other sources, for example as described above. The T or NK cells may be isolated from a subject's own peripheral blood (1st party), or in the setting of a haematopoietic stem cell transplant from donor peripheral blood (2nd party), or peripheral blood from an 25 unconnected donor (3rd party).

The present invention provides a CAR cell of the present invention for use in treating and/or preventing a disease.

30 The invention also relates to the use of a CAR cell of the present invention in the manufacture of a medicament for the treatment and/or prevention of a disease.

35 The disease to be treated and/or prevented by the methods of the present invention may be a cancerous disease, such as bladder cancer, breast cancer, colon cancer, endometrial cancer, kidney cancer (renal cell), leukaemia, lung cancer, melanoma, non-Hodgkin lymphoma, pancreatic cancer, prostate cancer and thyroid cancer.

Where the soluble ligand is PSA, the cancer may be prostate cancer.

The CAR cells of the present invention may be capable of killing target cells, such as cancer cells. The target cell may be characterised by the presence of a soluble ligand in the vicinity of the target cell. The target cell may be characterised by the presence of a soluble ligand together with the expression of a tumour-associated antigen (TAA) at the target cell surface.

The CAR cells of the present invention may be capable of killing target cells, such as cancer cells, which express a low density of the TAA. Examples of TAAs which are known to be expressed at low densities in certain cancers include, but are not limited to, ROR1 in CLL, Typr-1 in melanoma and BCMA in myeloma.

The CAR cells and pharmaceutical compositions of present invention may be for use in the treatment and/or prevention of the diseases described above.

The CAR cells and pharmaceutical compositions of present invention may be for use in any of the methods described above.

The invention will now be further described by way of Examples, which are meant to serve to assist one of ordinary skill in the art in carrying out the invention and are not intended in any way to limit the scope of the invention.

EXAMPLES

25

Example 1 – Triggering T-cell activation with a soluble ligand

Normally a CAR will not be activated with monomeric soluble ligand because the ligand just binds to the receptor without causing segregation of the engaged receptor (Figure 1). In order to aggregate receptors to a soluble ligand it is necessary to have at least two CARs that bind to two non-competitive epitopes (Figure 2). CARs are typically homodimers, but trimeric or multivalent receptors may show improved performance (Figure 3).

35 As a proof-of-concept, soluble monomeric ROR-1 was used as the ligand (Figure 4). Two CARs were used which bind to mutually exclusive epitopes on the ROR-1 ligand named R12 and R11. Following the aggregation model, it was predicted that T-cell

expressing either R11 or R12 will not activate with soluble ligand, but T-cell expressing both R12 and R11 will activate in the presence of soluble ligand. In order to stop the R12 and R11 CAR from cross binding to each other (causing a heterodimer) the R12 was placed on a CD8STK spacer and the R11 on an Fc spacer 5 (Figure 5). As a control a dual CAR expressing T-cell was used where both CARs contain the R12 scFv (one on a CD8STK and the other on an Fc spacer). In order to investigate the effect of having one of the CARs as a multivalent CAR, in one system the R12 CAR was placed on a CD8STK spacer and the R11 on a COMP spacer (Figure 6).

10

A mouse T-cell line (BW5 cells) was transduced with either a single CAR that contained an R12 scFv on a CD8STK or Fc spacer or a single CAR that contained an R11 scFv on a Fc or COMP spacer. In addition BW5 cells that were positive for R12-CD8STK were transduced to express a second CAR that was either R11-Fc, R11-15 COMP or, as a control, R12-Fc. All CARs used in this experiment had an intracellular TCRz domain (1st generation). These cells were stimulated with supernatant containing soluble ROR-1 (His tagged) and the IL-2 was measured after 24h (Figure 7).

20 In was found that only T-cells that expressed both the R11 and R12 CAR were able to stimulate in the presence of soluble ligand. Importantly the T-cell expressing two copies of R12 was not able to stimulate with soluble ligand.

25 As a further control to test that these T-cells were able to be stimulated with immobilised ligand, these T-cells were stimulated with anti-His beads that were pre-coated with different concentrations of the soluble ROR-1 his tag (Figure 8). This figure shows that all T-cells were able to be stimulated with immobilised ligand, indicating that all the T-cells used in this experiment were capable of transmitting a signal however only a dual CAR to two mutually exclusive epitopes was able to be 30 stimulated with soluble ligand.

Example 2 – The use of aggregation-based AND gate to trigger T-cell activation in the presence of both a membrane-bound ligand and a soluble ligand.

35 In order to demonstrate the feasibility of a "Split" CAR system BW5 cells were transduced with a vector expressing either:

- i) aCD19-CD8STK-TCRz-2A-R12-IgGFc-CD148 or

ii) aCD19-CD8STK-TCRz-2A-R12-IgGFc-CD148 and R11-IgMFc-CD148

and exposed to either non-transfected SupT1 target cells or SupT1 target cells expressing CD19. A co-culture was carried out with a 4:1 target to effector ratio with 5 different concentrations of soluble ROR-1 supernatants.

The results are shown in Figure 14. T cell activation is maximal in the presence of both the membrane-bound antigen (CD19) and the soluble ligand (ROR1). Targets which did not express the membrane-bound antigen (NT) did not give T-cell 10 stimulation.

Example 3 – Induced aggregation with subsequent T cell activation occurs with the soluble ligand PSA, using a two-CAR system based on the PSA-binding mAbs (5D5A5 and 5D5D11).

15

BW5 T-cells were transduced with a vector expressing;

- i) A5-D11 (aPSA-A5-CD8STK-CD28TM-z_aPSA-D11-HL-Hinge-CD28tmZ), or
- ii) D11-A5 (aPSA-D11-CD8STK-CD28TM-z_aPSA-A5-HL-Hinge-CD28tmZ)

and then incubated in the presence of 300 pg/mL PSA, to determine whether the PSA 20 antigen binding domains in the construct of the two CAR system induces aggregation with subsequent CAR activation. The graph (Figure 15) shows that both A5-D11 and D11-A5 constructs resulted in the BW5 T-cells secreting significant levels of IL-2, indicating T-cell activation.

25 All publications mentioned in the above specification are herein incorporated by reference. Various modifications and variations of the described methods and system of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the 30 invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention which are obvious to those skilled in molecular biology or related fields are intended to be within the scope of the following claims.

35

CLAIMS

1. A cell which comprises a first chimeric antigen receptor (CAR) and a second CAR, wherein the first and second CARs bind different epitopes on the same ligand.

5

2. A cell according to claim 1, wherein the ligand is a soluble ligand.

3. A cell according to claim 2, wherein the ligand is a cytokine, chemokine or metabolite.

10

4. A cell according to any preceding claim, wherein each CAR comprises
(i) an antigen-binding domain;
(ii) a spacer; and
(iii) a trans-membrane domain

15 wherein the spacers of the first and second CARs are different.

5. A cell according to any preceding claim, wherein each CAR comprises
(i) an antigen-binding domain;
(ii) a spacer; and
20 (iii) a trans-membrane domain

wherein the spacers of the first and/or second CAR(s) is/are trimeric or multi-valent.

6. A cell according to any preceding claim which comprises a third CAR which binds a cell surface antigen.

25

7. A cell according to claim 6, wherein the first and/or second and third CARs each comprise:

(i) an antigen-binding domain;
(ii) a trans-membrane domain; and
30 (iii) an endodomain

wherein the endodomains of the third CAR and the first and/or second CAR(s) are complementary, such that cell activation occurs when the ligand is bound by the first and second CARs and the cell surface antigen is bound by the third CAR.

35 8. A cell according to claim 7, wherein the third CAR comprises a CD3 zeta endodomain, and the first and/or second CAR(s) comprise a CD28 endodomain and a OX40 or 41BB endodomain.

9. A cell according to any of claims 6 to 8 wherein the third CAR binds prostate-specific membrane antigen (PSMA) and the first and second CARs bind prostate-specific antigen (PSA).

5 10. A cell according to claim 6, wherein the first and/or second CAR(s) comprise(s) an inhibitory endodomain, such that when the first and second CARs bind the ligand, cell activation caused by the third CAR binding the cell surface antigen is inhibited.

10 11. A cell according to claim 2, wherein the first CAR comprises two antigen binding domains: one which binds the soluble ligand; and one which binds a cell-surface antigen.

15 12. A cell according to any of claims 1 to 5, wherein the second CAR comprises an inhibitory endodomain, such that when the first and second CARs bind the soluble ligand, cell activation caused by the first CAR binding the cell surface antigen is inhibited.

20 13. A cell according to claim 10 or 12, wherein the inhibitory endodomain is or comprises the catalytic domain of PTPN6 or an Immunoreceptor Tyrosine-based Inhibition motif (ITIM).

14. A cell according to any of claims 10 to 13 wherein the first and second CARs bind IL-6.

25 15. A cell according to claim 6, wherein the first and/or second CAR(s) comprise(s) an inhibitory endodomain, such that:

in the absence of the ligand, cell activation caused by the third CAR binding the cell surface antigen is inhibited; and

30 in the presence of ligand, the first and second CARs aggregate and segregate from the third CAR, so that signalling can occur when the third CAR binds the cell surface antigen.

16. A cell according to claim 15, wherein the inhibitory endodomain is or 35 comprises the endodomain of CD45 or CD148.

17. A cell according to claim 11, wherein the first CAR lacks a functional endodomain and wherein the second CAR is monomeric and comprises a functional endodomain, such that binding of the soluble ligand causes co-localisation of the first and second CARs and enables T-cell signalling to occur when the first CAR binds the

5 cell surface antigen.

18. A cell according to claim 17, wherein the second CAR comprises a monomeric spacer.

10 19. A cell according to claim 18, wherein the monomeric spacer comprises one or more Ig domains from CD22.

20. A cell according to any of claims 17 to 19, wherein the functional endodomain on the second CAR comprises the CD3-zeta endodomain.

15 21. A nucleic acid construct which comprises a first nucleic acid sequence encoding a first CAR as defined in any of claims 1 to 20; and a second nucleic acid sequence encoding a second CAR as defined in any of claims 1 to 20.

22. A nucleic acid construct according to claim 21, which has the following
20 structure:

AgB1-spacer1-TM1-endo1-coexpr-AbB2-spacer2-TM2-endo2

in which

25 AgB1 is a nucleic acid sequence encoding the antigen-binding domain of the first CAR;

spacer 1 is a nucleic acid sequence encoding the spacer of the first CAR;

TM1 is a nucleic acid sequence encoding the transmembrane domain of the first CAR;

30 endo 1 is a nucleic acid sequence encoding the endodomain of the first CAR;

coexpr is a nucleic acid sequence enabling co-expression of both CARs

AgB2 is a nucleic acid sequence encoding the antigen-binding domain of the second CAR;

spacer 2 is a nucleic acid sequence encoding the spacer of the second CAR;

35 TM2 is a nucleic acid sequence encoding the transmembrane domain of the second CAR;

endo 2 is a nucleic acid sequence encoding the endodomain of the second CAR;

which nucleic acid construct, when expressed in a T cell, encodes a polypeptide which is cleaved at the cleavage site such that the first and second CARs are co-expressed at the T cell surface.

5 23. A nucleic acid construct according to claim 22, wherein coexpr encodes a sequence comprising a self-cleaving peptide.

24. A nucleic acid construct according to claim 22 or 23, wherein alternative codons are used in regions of sequence encoding the same or similar amino acid 10 sequences, in order to avoid homologous recombination.

25. A nucleic acid construct according to any of claims 21 to 24, which also comprises a nucleic acid sequence encoding a third CAR as defined in any of claims 6 to 10, 15 and 16.

15 26. A vector comprising a nucleic acid construct according to any of claims 21 to 25.

27. A retroviral vector or a lentiviral vector or a transposon according to claim 26.

20 28. A kit which comprises:
i) a vector comprising a nucleic acid sequence encoding a first CAR as defined in any of claims 1 to 5; and
ii) a vector comprising a nucleic acid sequence encoding a second CAR as 25 defined in any of claims 1 to 5.

29. A kit according to claim 28 which also comprises a vector comprising a nucleic acid sequence encoding a third CAR as defined in claim 6.

30 30. A method for making a cell according to any of claims 1 to 20, which comprises the step of introducing: a nucleic acid construct according to any of claims 21 to 25; a vector according to claim 26 or 27; or a kit of vectors according to claim 28 or 29, into a cell.

35 31. A method according to claim 30, wherein the cell is from a sample isolated from a subject.

32. A pharmaceutical composition comprising a plurality of cells according to any of claims 1 to 20.

5 33. A method for treating and/or preventing a disease, which comprises the step of administering a pharmaceutical composition according to claim 32 to a subject.

34. A method according to claim 33, which comprises the following steps:

(i) isolation of a cell-containing sample from a subject;

(ii) transduction or transfection of the cells with: a nucleic acid construct

10 according to any of claims 21 to 25; a vector according to claim 26 or 27; or a kit of vectors according to claim 28 or 29; and

(iii) administering the cells from (ii) to a the subject.

35. A method according to claim 34, wherein the sample is a T-cell containing
15 sample.

36. A method according to claim 34 or 35, wherein the disease is a cancer.

37. A pharmaceutical composition according to claim 32 for use in treating and/or
20 preventing a disease.

38. The use of a cell according to any of claims 1 to 20 in the manufacture of a medicament for treating and/or preventing a disease.

1/18

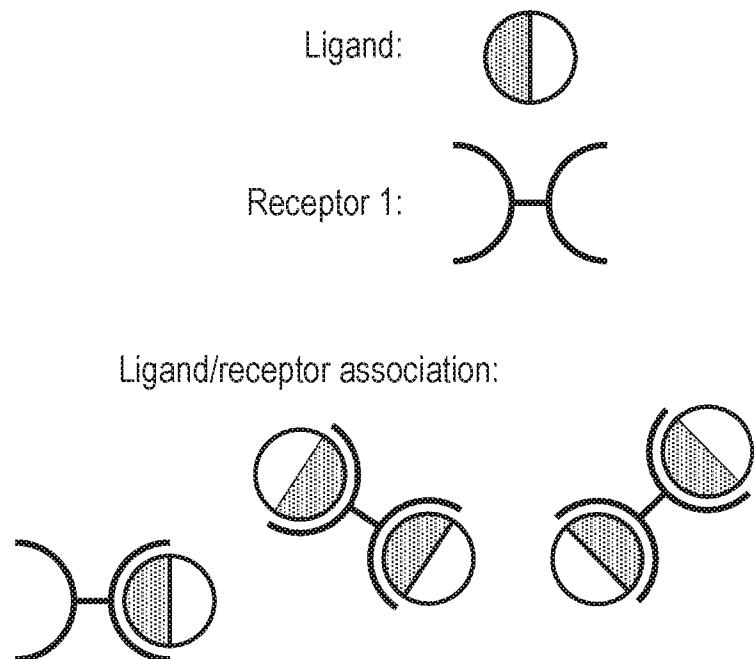


FIG. 1

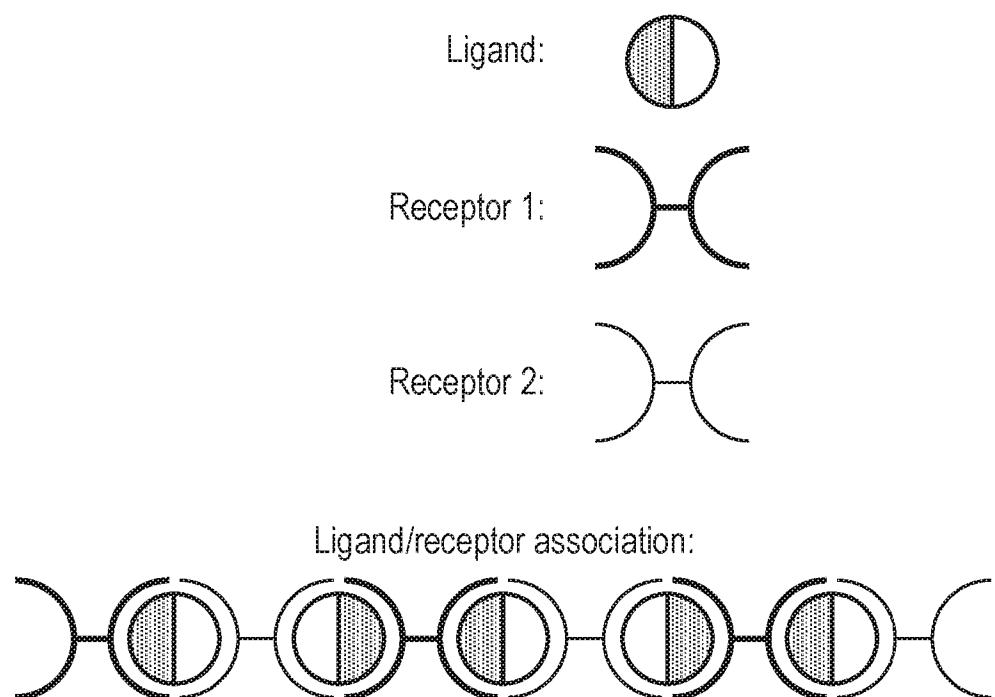


FIG. 2

2/18

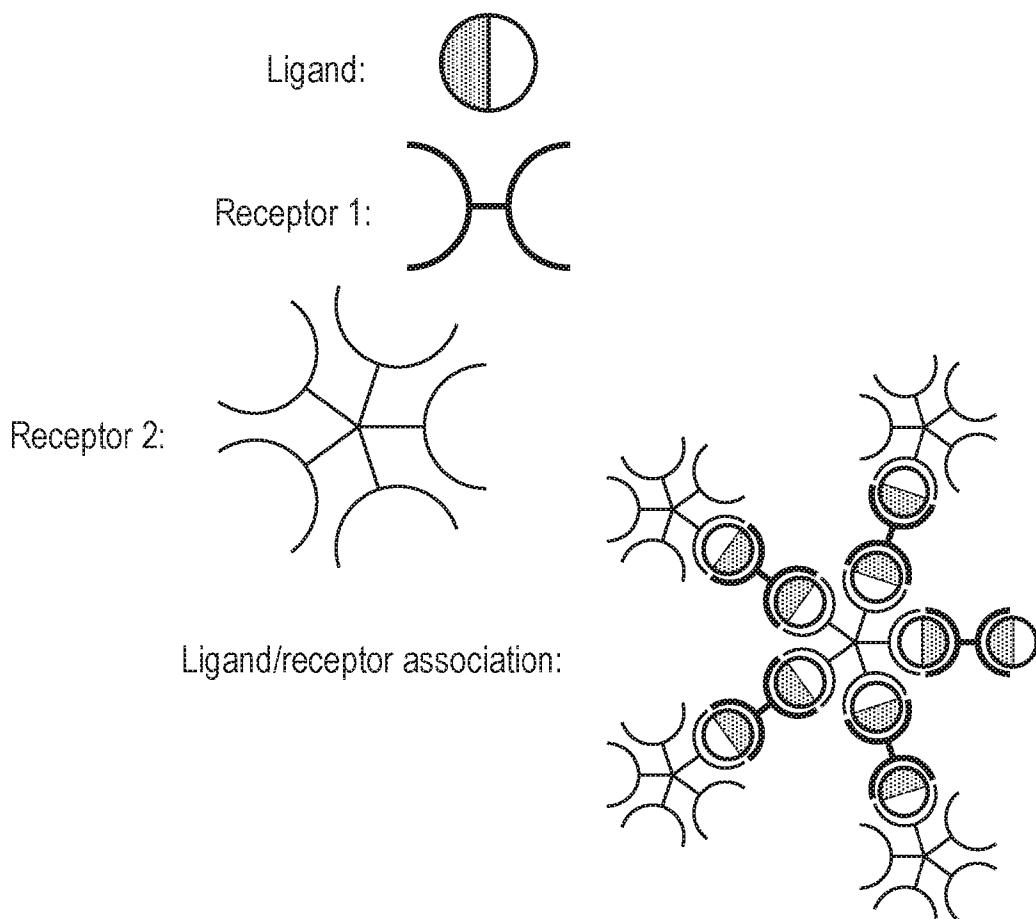


FIG. 3

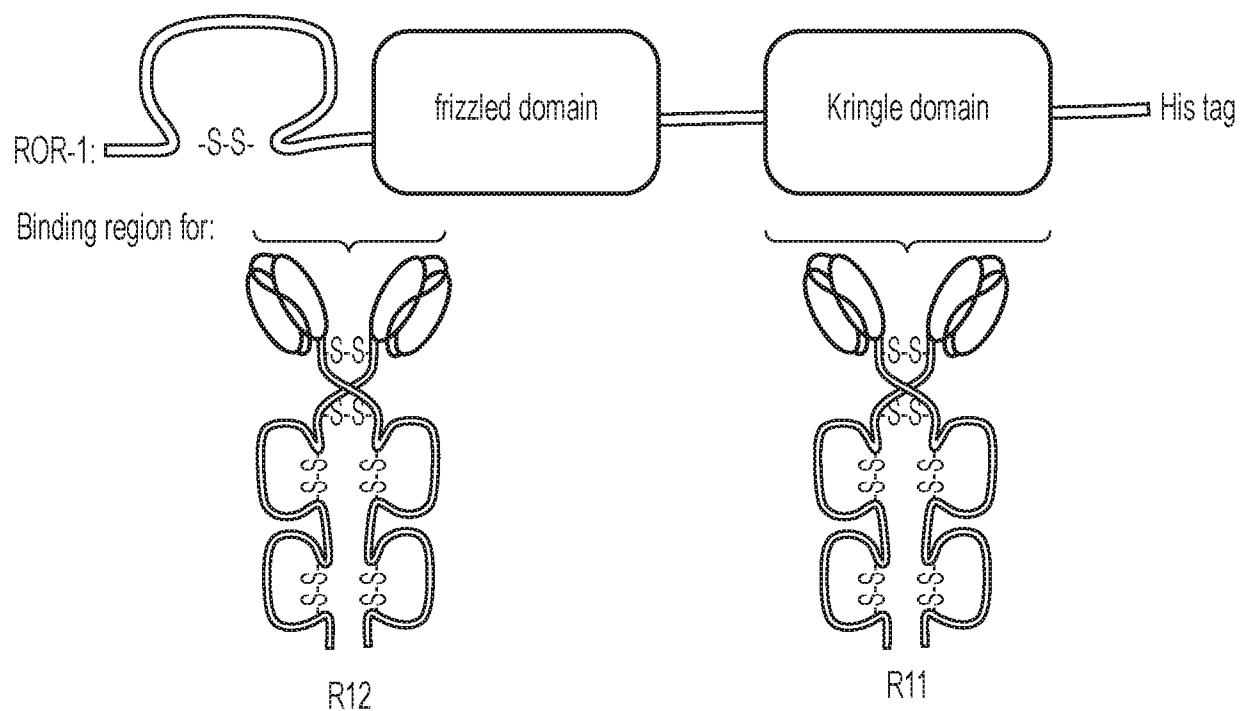


FIG. 4

3/18

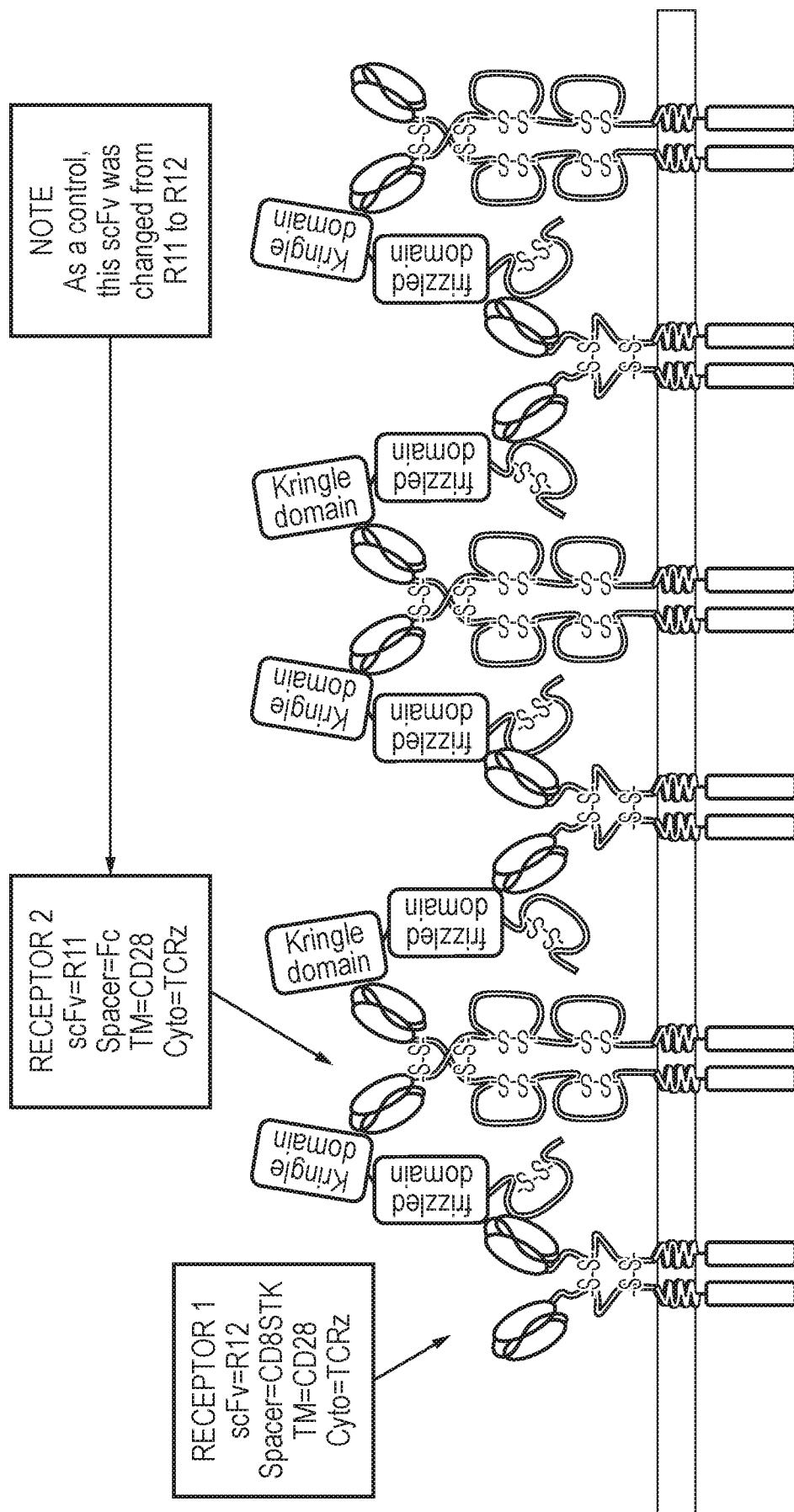


FIG. 5

4/18

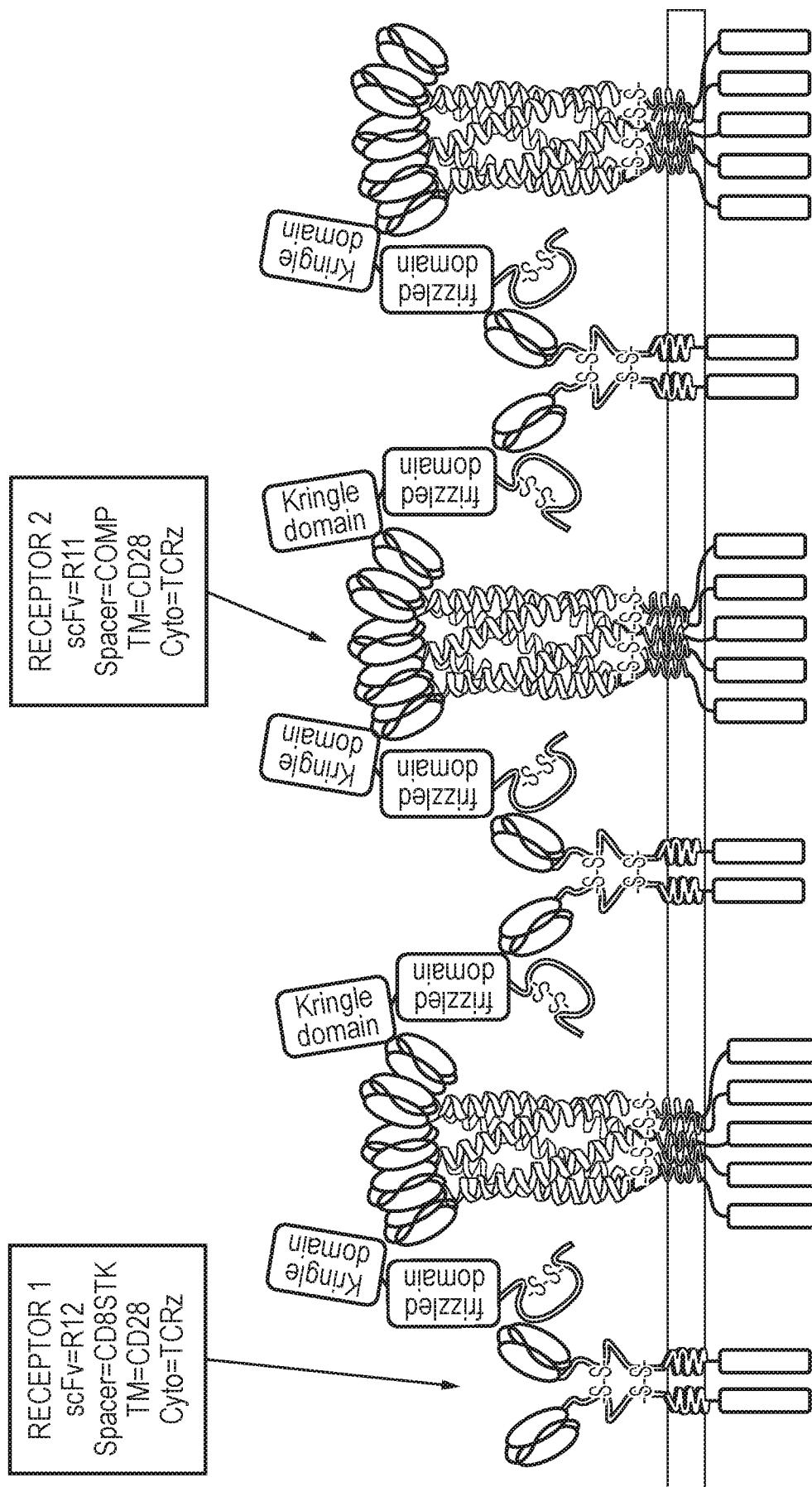
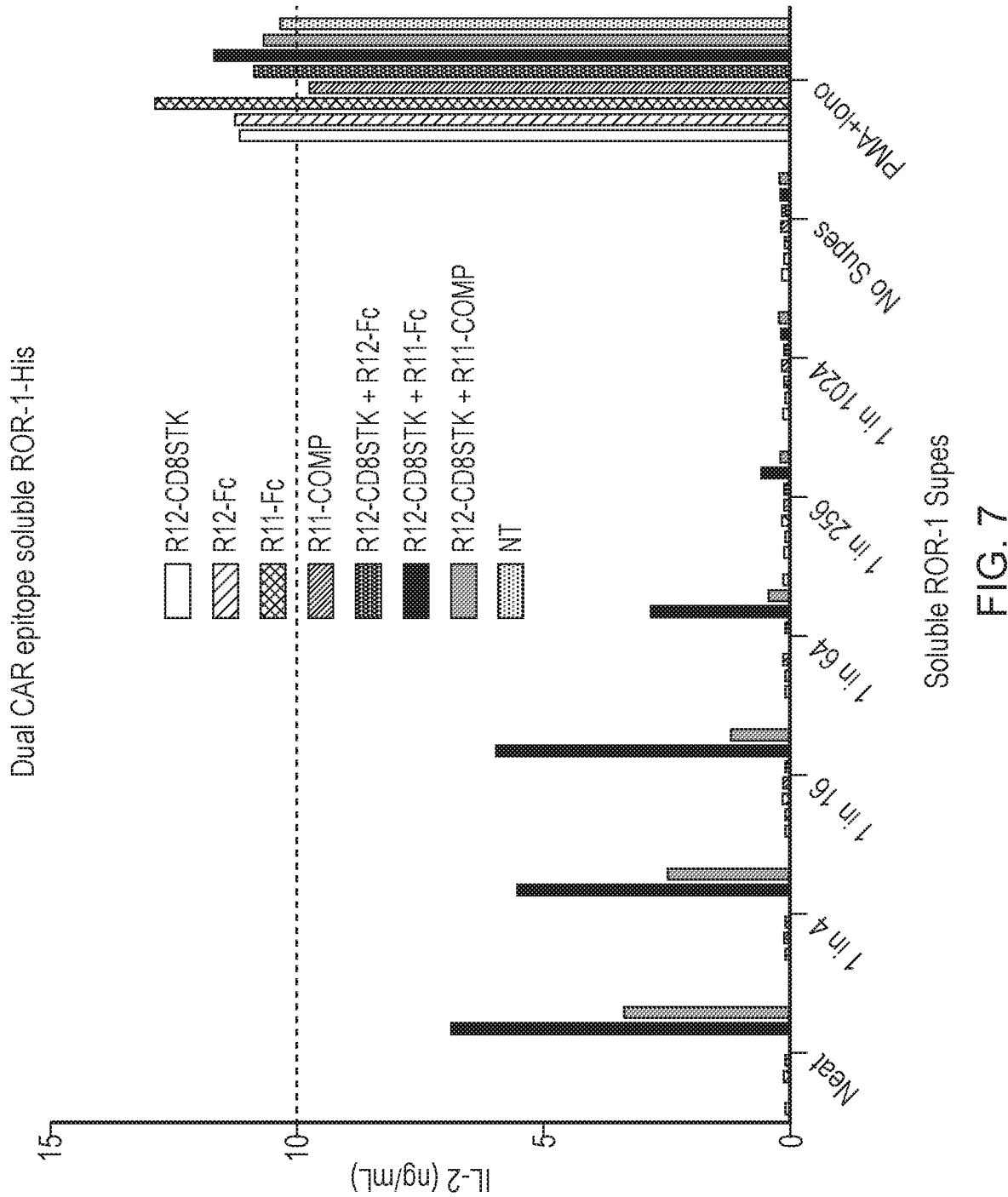


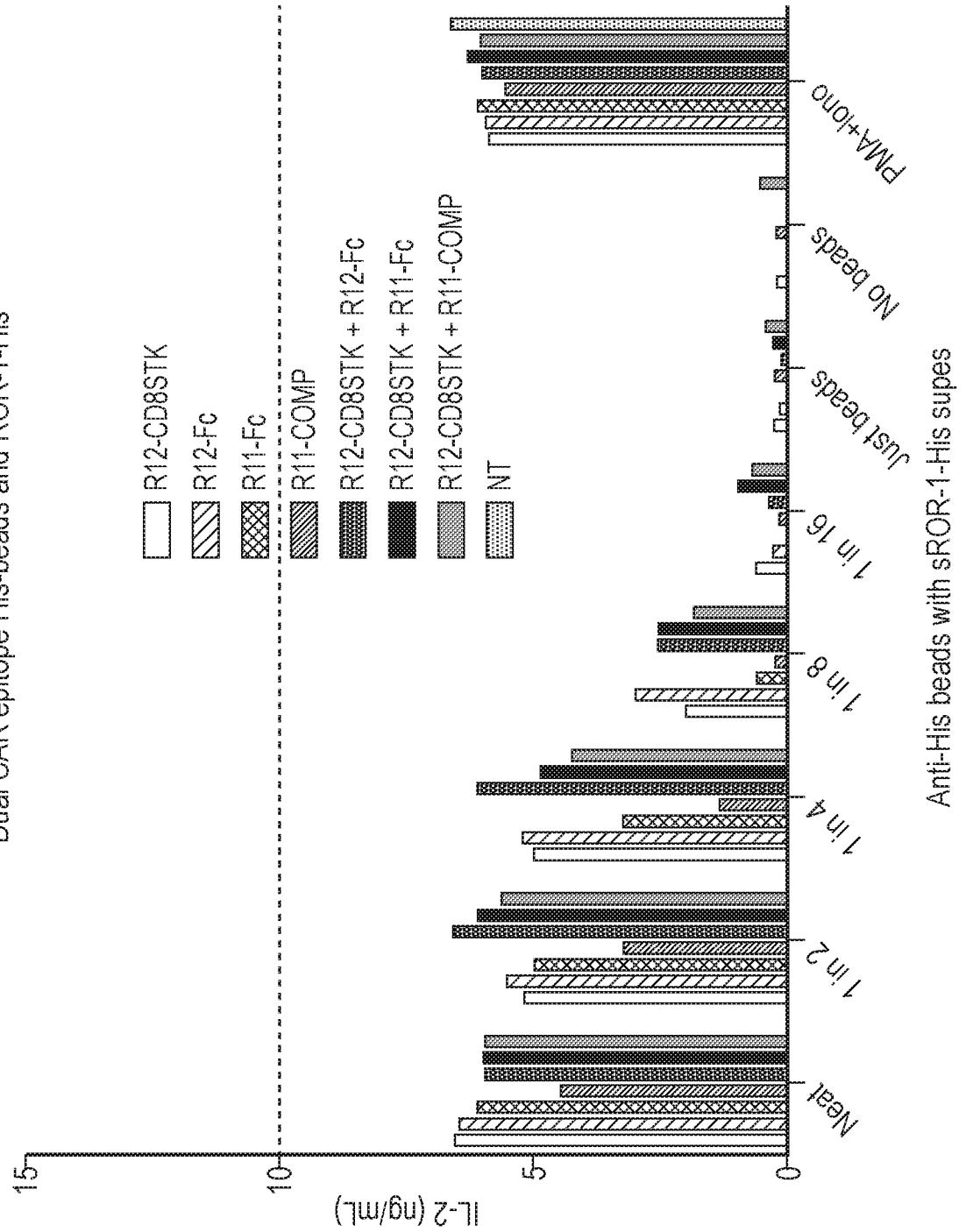
FIG. 6

5/18



6/18

Dual CAR epitope His-beads and ROR-1-His



7/18

Enhancer CAR

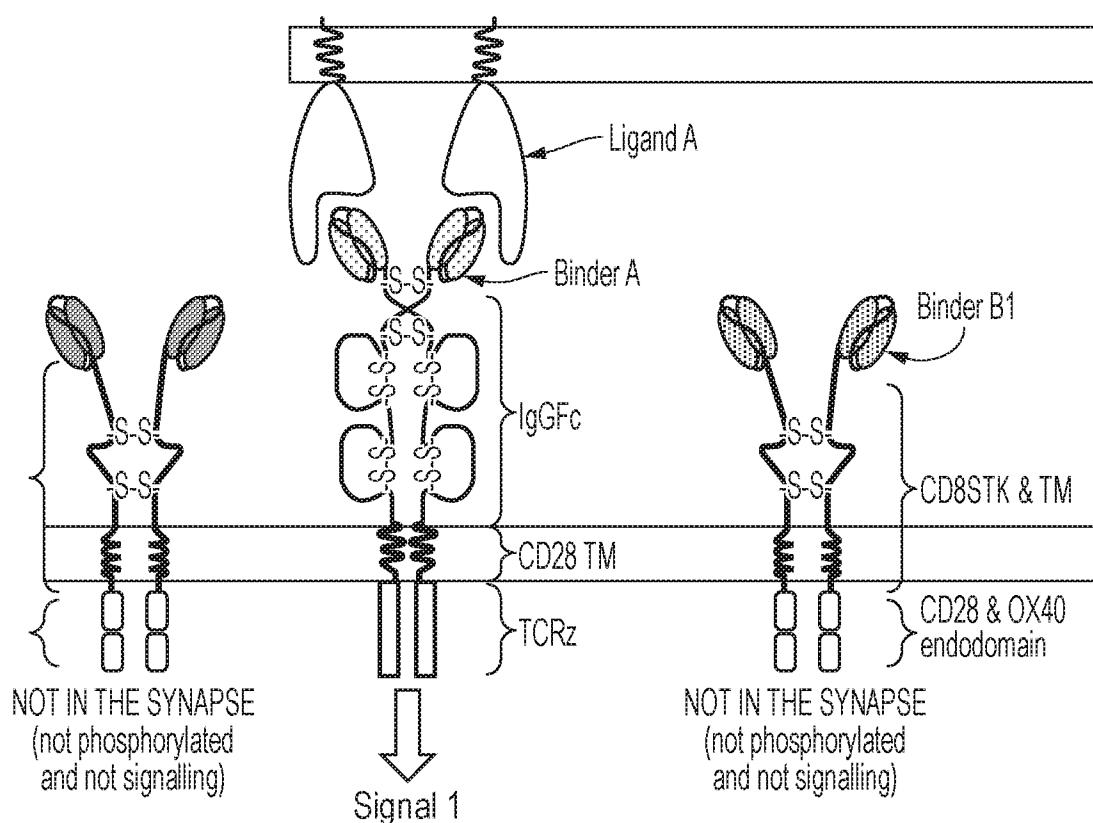
Ligand A+

FIG. 9

8/18

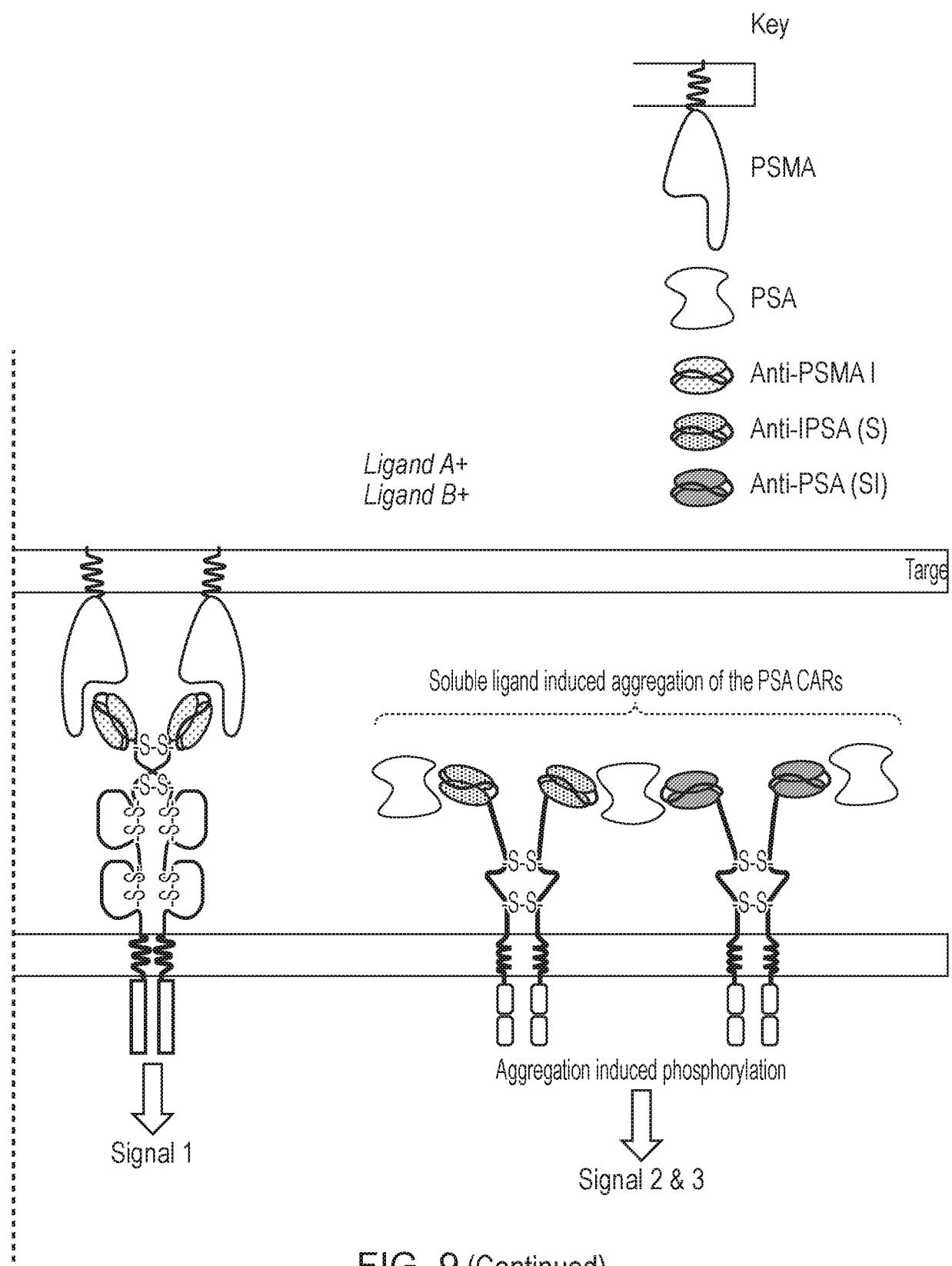


FIG. 9 (Continued)

9/18

ANDNOT

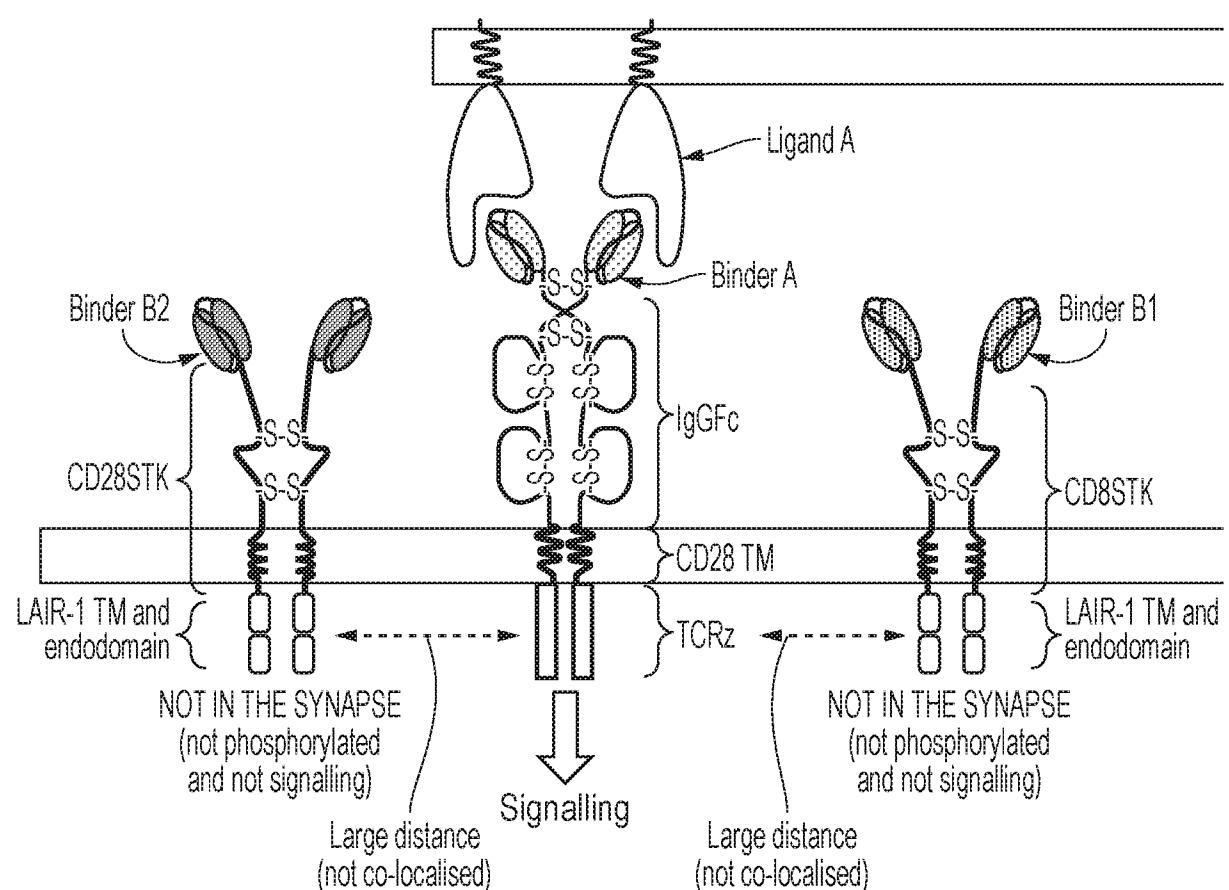
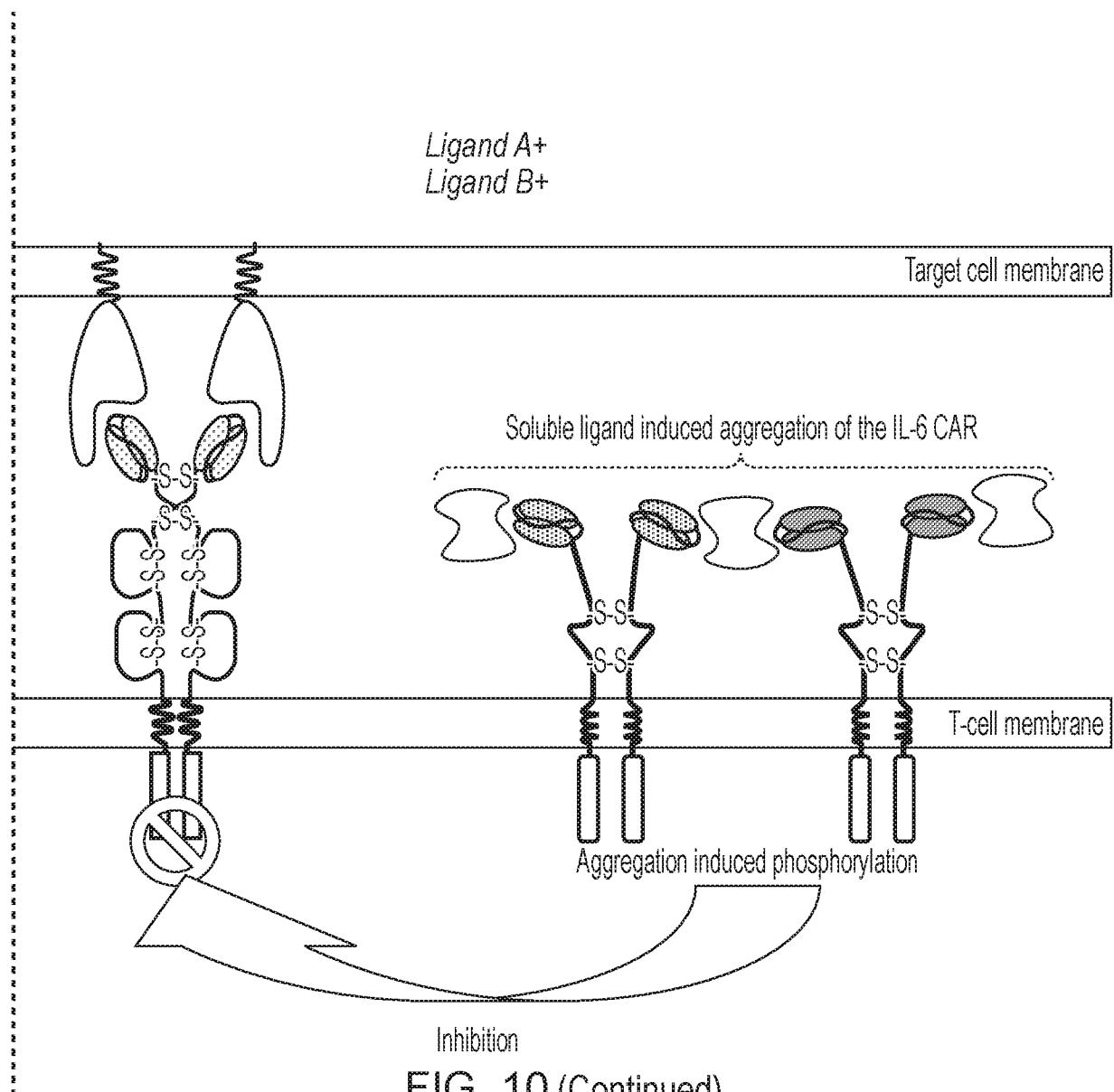
Ligand A+

FIG. 10

10/18



11/18

ANDNOT

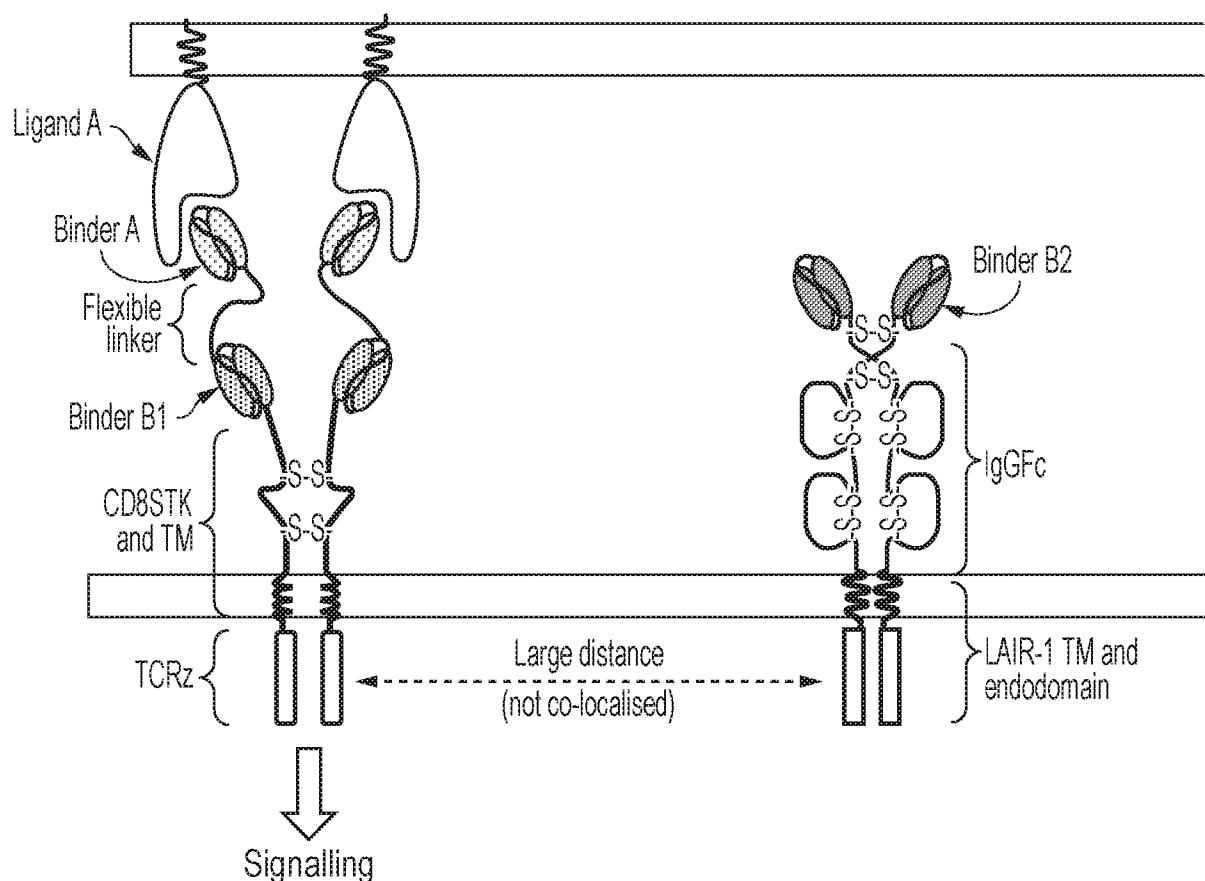
Ligand A+

FIG. 11

12/18

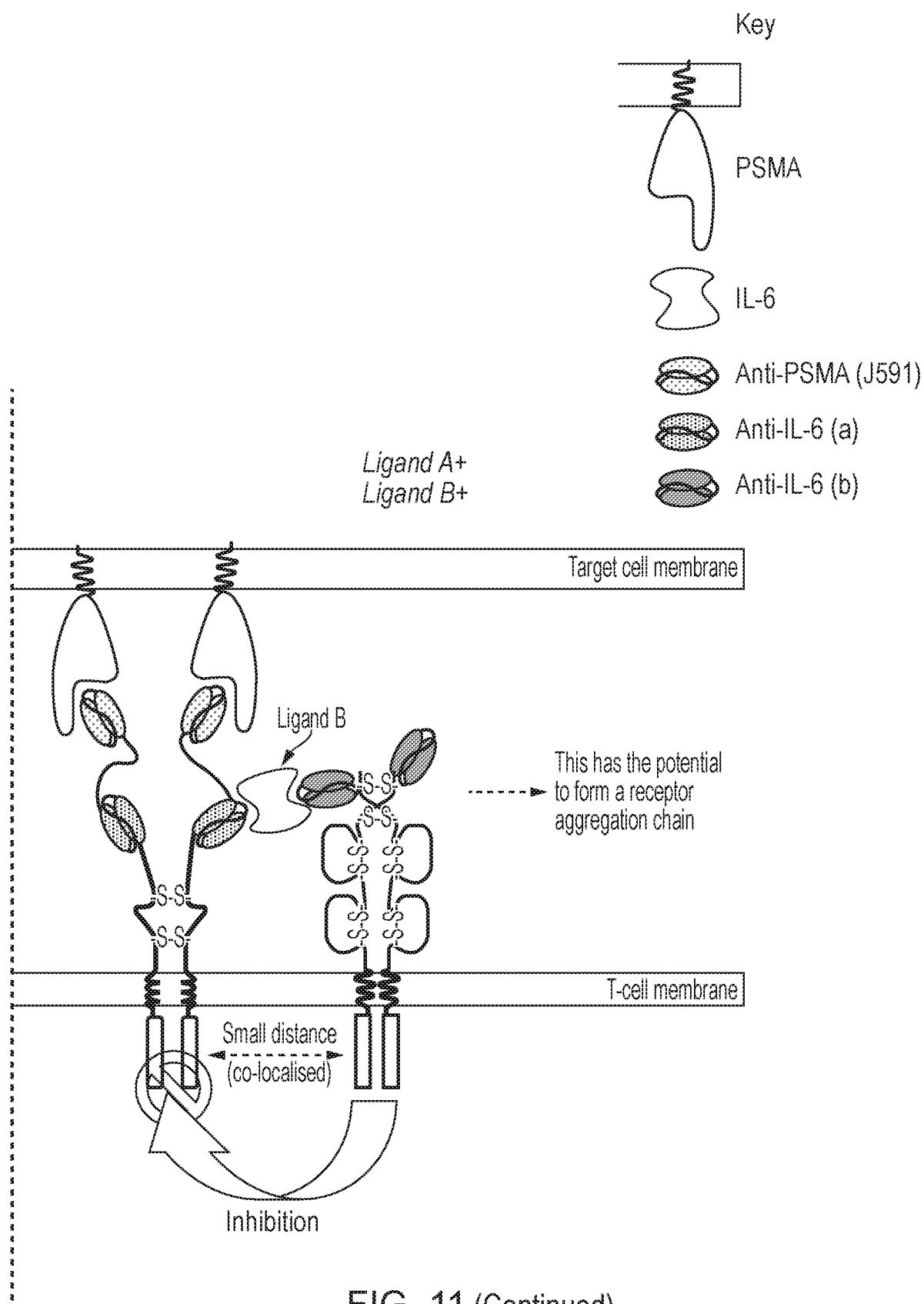


FIG. 11 (Continued)

13/18

AND

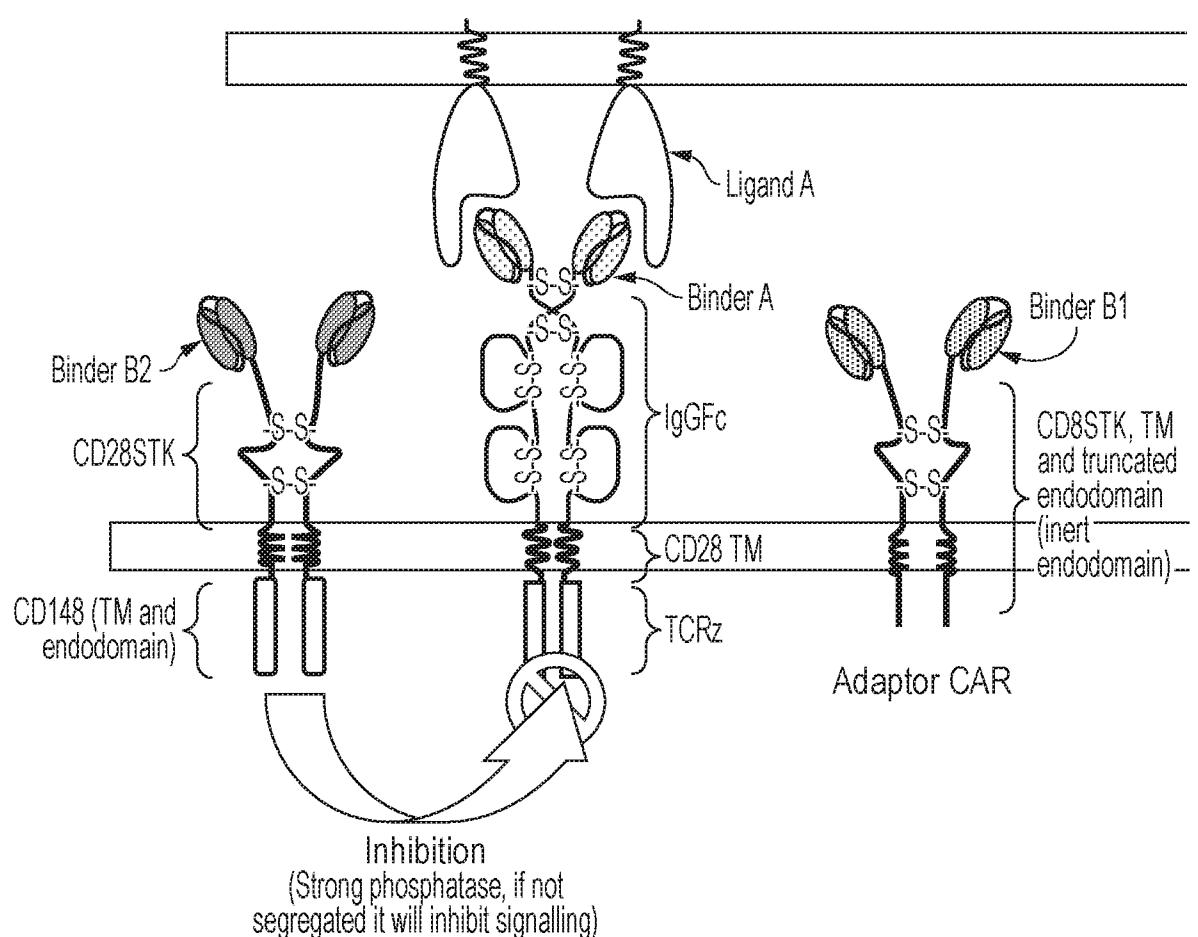
Ligand A+

FIG. 12

14/18

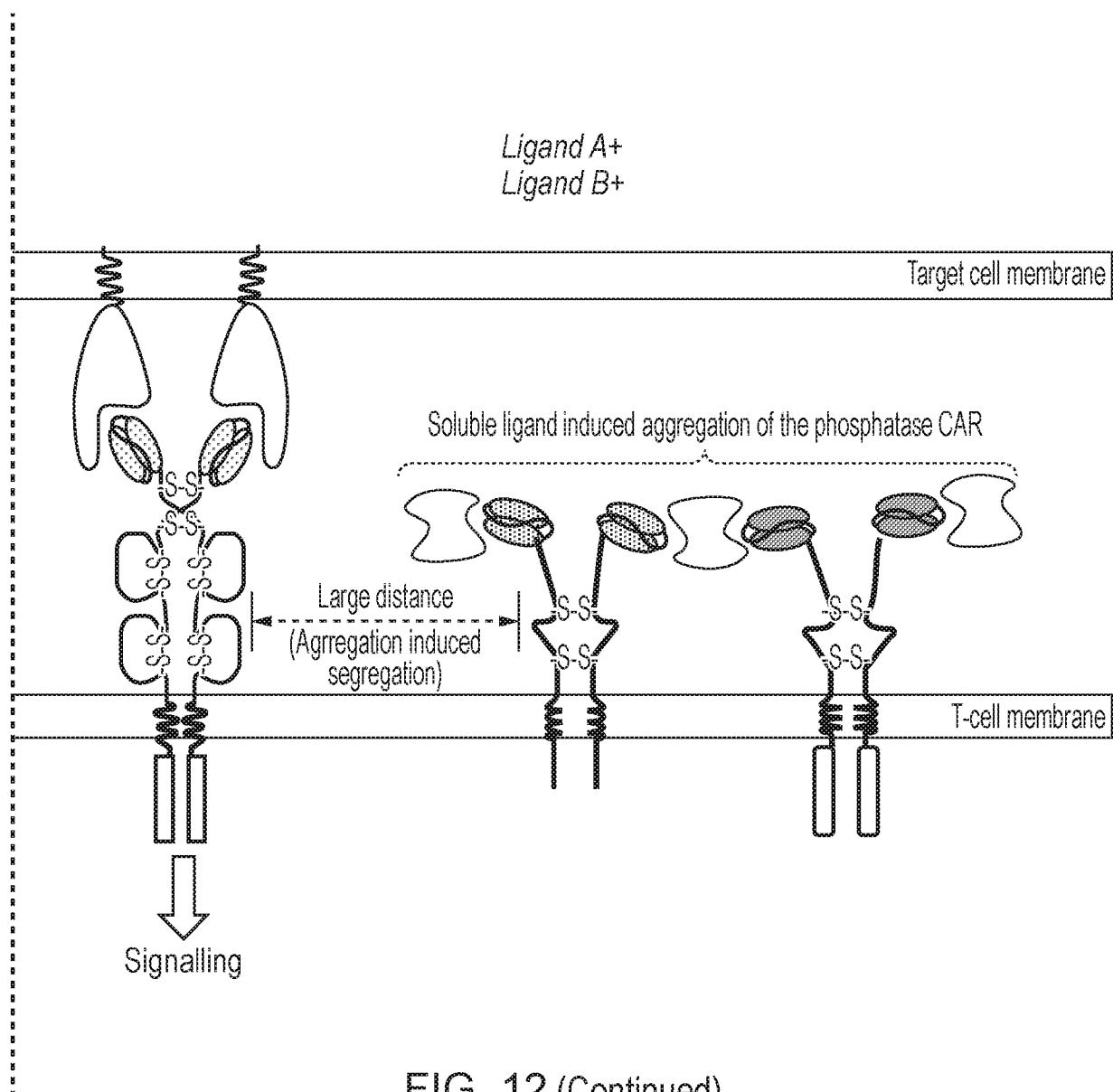


FIG. 12 (Continued)

15/18

AND

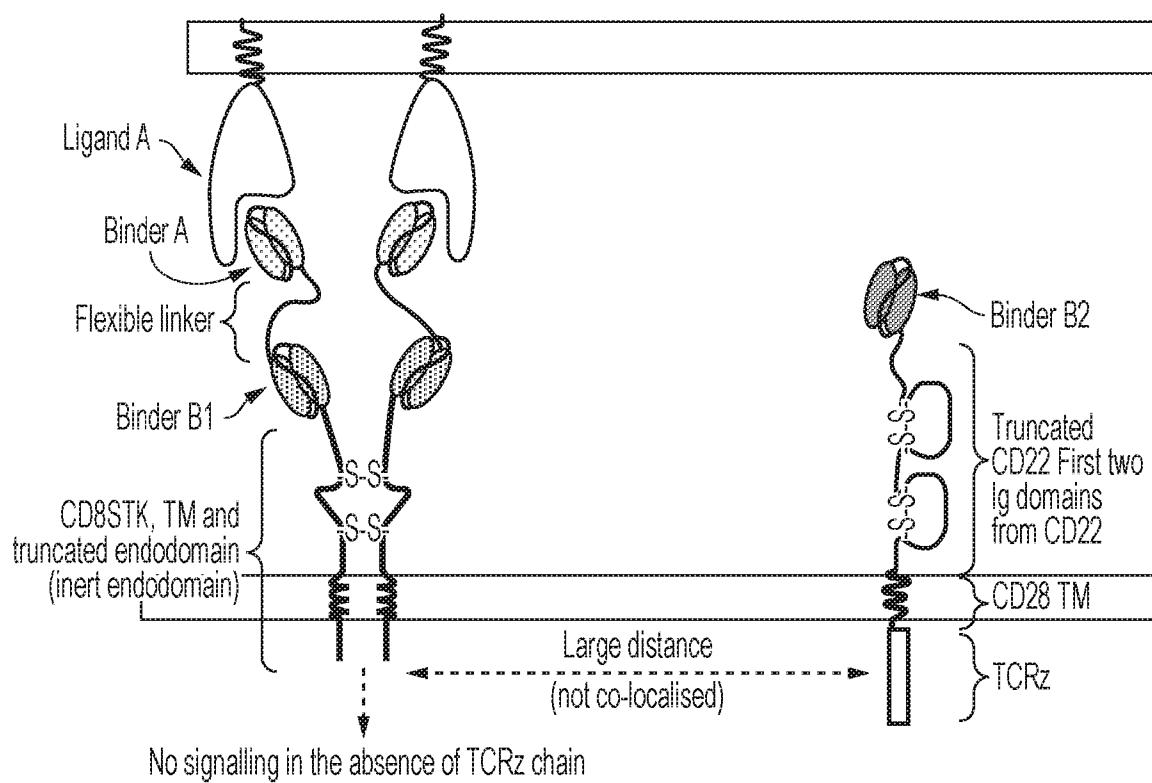
Ligand A+

FIG. 13

16/18

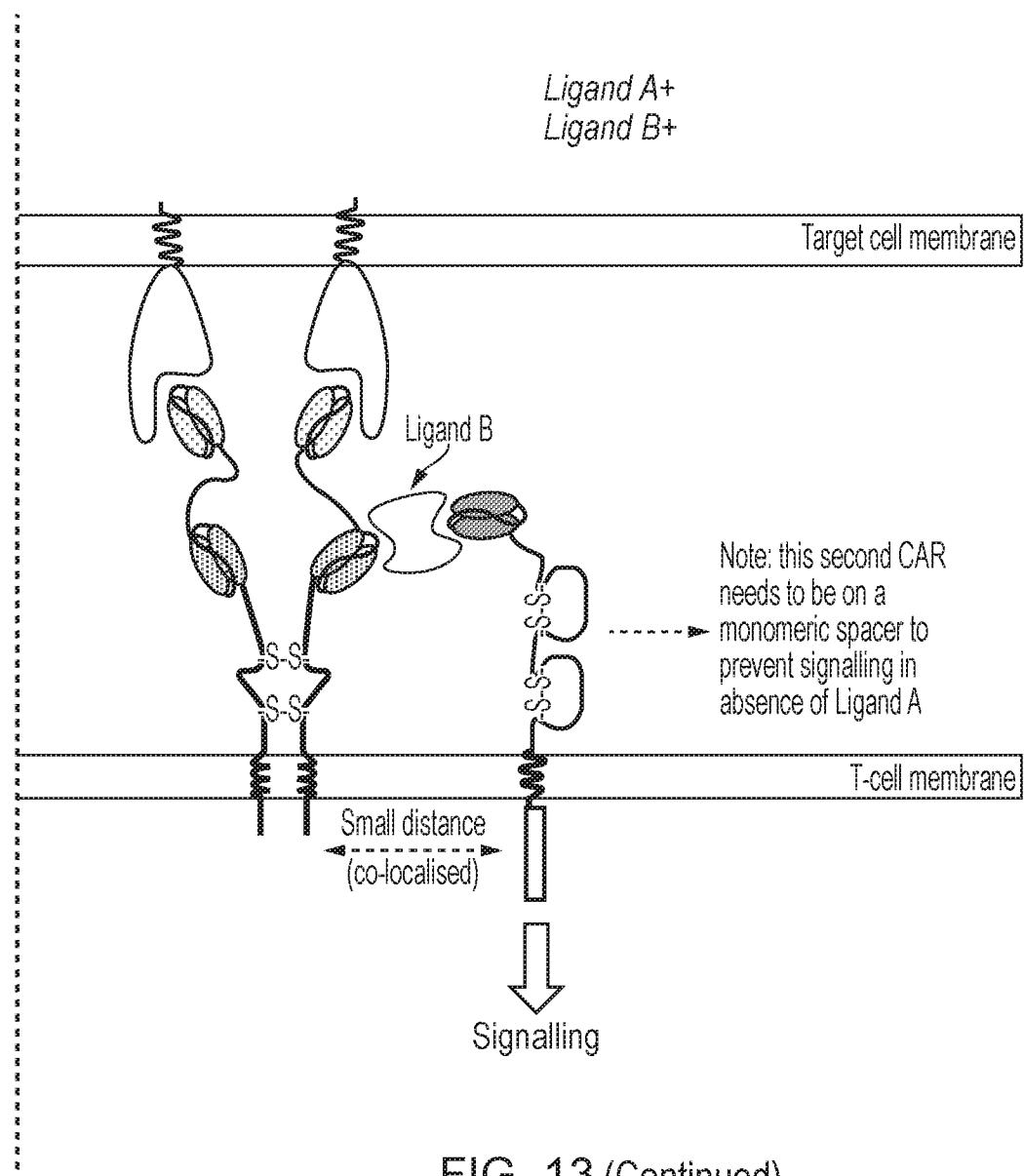


FIG. 13 (Continued)

17/18

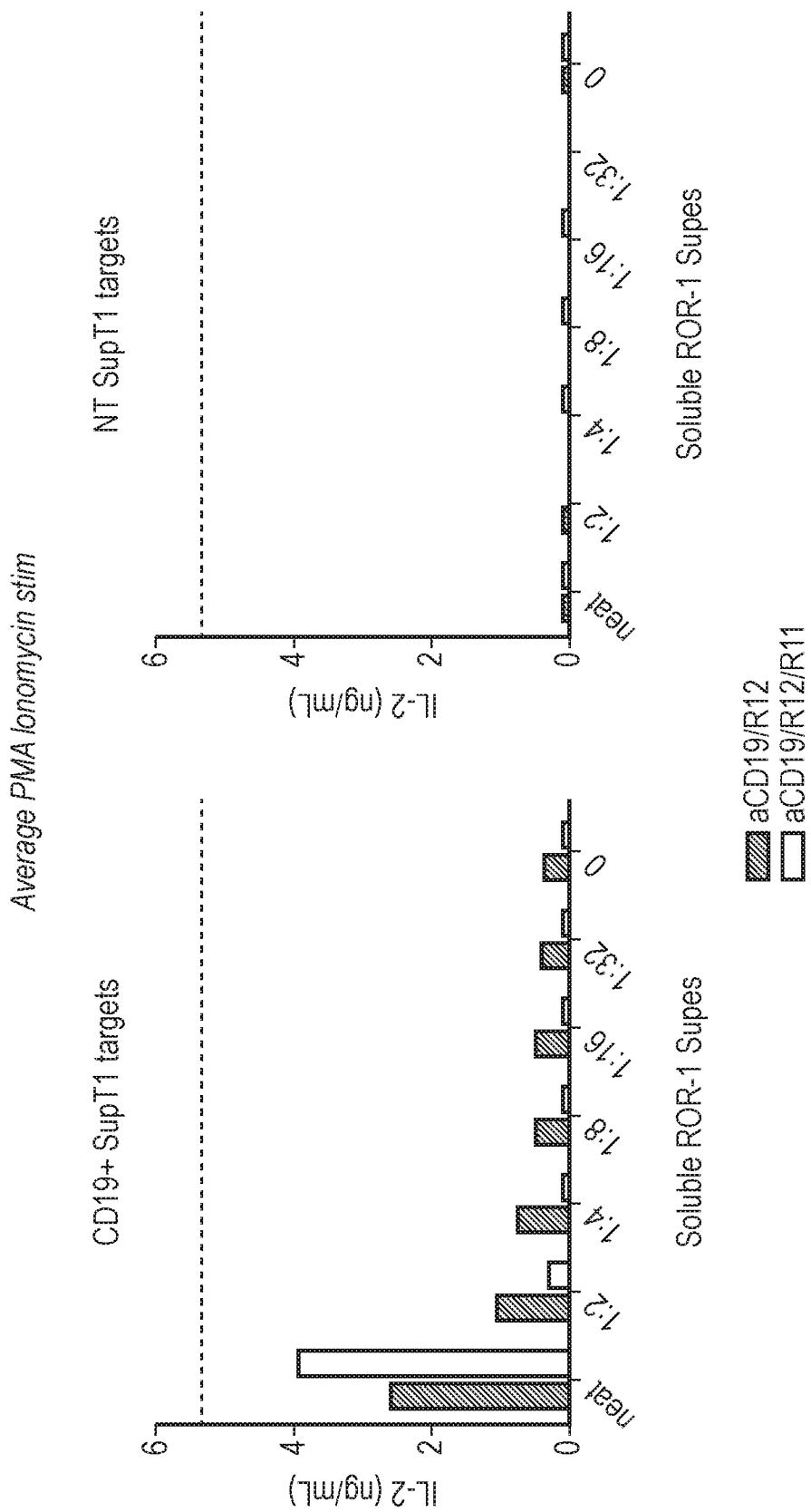


FIG. 14

18/18

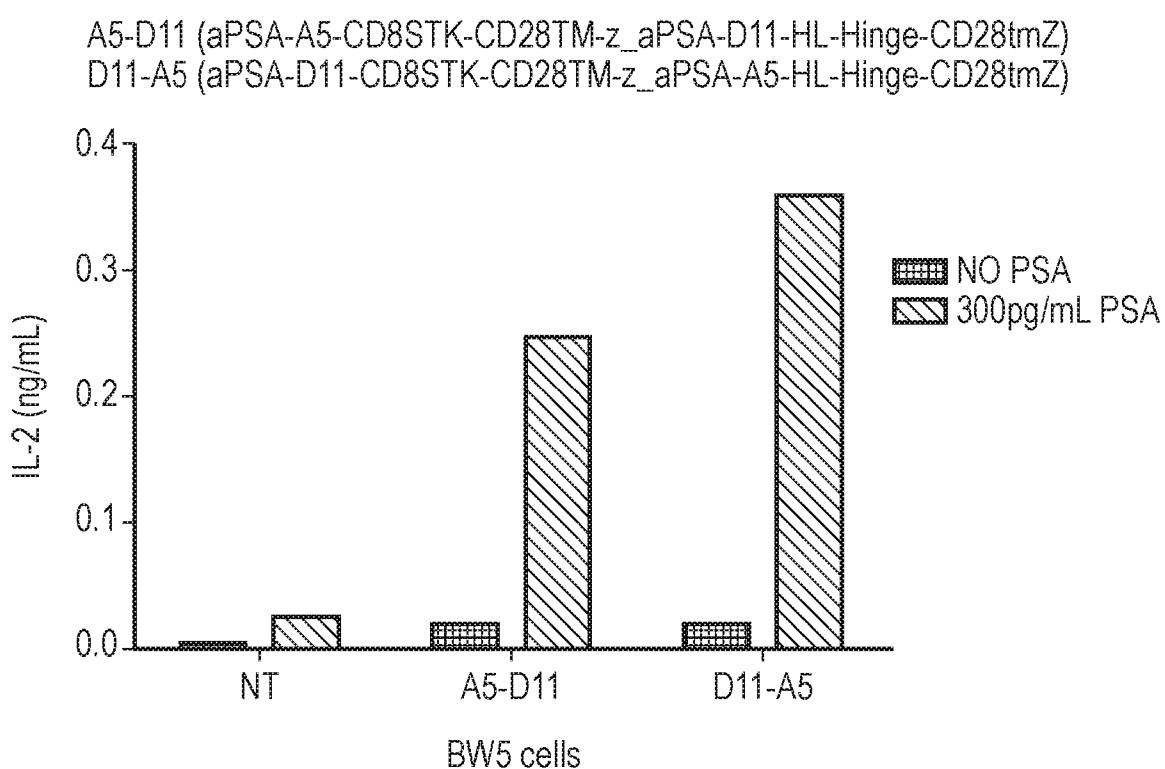


FIG. 15

pctgb2016052563-seqI
SEQUENCE LISTING

<110> Autolus Ltd
<120> Cell
<130> P106882PCT
<150> GB1514874.5
<151> 2015-08-20
<160> 64
<170> PatentIn version 3.5

<210> 1
<211> 118
<212> PRT
<213> Artificial Sequence

<220>
<223> sequence of 5D3D11 VH

<400> 1

Gl n Val Gl n Leu Gl n Gl n Ser Gl y Pro Gl u Leu Val Lys Pro Gl y Al a
1 5 10 15

Ser Val Lys Ile Ser Cys Lys Val Ser Gl y Tyr Al a Ile Ser Ser Ser
20 25 30

Trp Met Asn Trp Val Lys Gl n Arg Pro Gl y Gl n Gl y Leu Gl u Trp Ile
35 40 45

Gl y Arg Ile Tyr Pro Gl y Asp Gl y Asp Thr Lys Tyr Asn Gl y Lys Phe
50 55 60

Lys Asp Lys Al a Thr Leu Thr Val Asp Lys Ser Ser Ser Thr Al a Tyr
65 70 75 80

Met Gl n Leu Ser Ser Leu Thr Ser Val Asp Ser Al a Val Tyr Phe Cys
85 90 95

Al a Arg Asp Gl y Tyr Arg Tyr Tyr Phe Asp Tyr Trp Gl y Gl n Gl y Thr
100 105 110

Ser Val Thr Val Ser Ser
115

<210> 2
<211> 112
<212> PRT
<213> Artificial Sequence

<220>
<223> sequence of 5D3D11 VL

<400> 2

Asp Ile Val Met Thr Gl n Thr Al a Pro Ser Val Phe Val Thr Pro Gl y
Page 1

1

5

10

15

Gl u Ser Val Ser Ile Ser Cys Arg Ser Ser Lys Ser Leu Leu His Ser
 20 25 30

Asn Gl y Asn Thr Tyr Leu Tyr Trp Phe Leu Gl n Arg Pro Gl y Gl n Ser
 35 40 45

Pro Gl n Leu Leu Ile Tyr Arg Met Ser Asn Leu Al a Ser Gl y Val Pro
 50 55 60

Asp Arg Phe Ser Gl y Ser Gl y Ser Gl y Thr Asp Phe Thr Leu Arg Ile
 65 70 75 80

Ser Arg Val Gl u Al a Gl u Asp Val Gl y Val Tyr Tyr Cys Met Gl n His
 85 90 95

Leu Gl u Tyr Pro Val Thr Phe Gl y Al a Gl y Thr Lys Val Gl u Ile Lys
 100 105 110

<210> 3

<211> 117

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of 5D5A5 VH

<400> 3

Gl n Val Gl n Leu Gl n Gl n Ser Gl y Al a Gl u Leu Al a Lys Pro Gl y Al a
 1 5 10 15

Ser Val Lys Met Ser Cys Lys Thr Ser Gl y Tyr Ser Phe Ser Ser Tyr
 20 25 30

Trp Met His Trp Val Lys Gl n Arg Pro Gl y Gl n Gl y Leu Gl u Trp Ile
 35 40 45

Gl y Tyr Ile Asn Pro Ser Thr Gl y Tyr Thr Gl u Asn Asn Gl n Lys Phe
 50 55 60

Lys Asp Lys Val Thr Leu Thr Al a Asp Lys Ser Ser Asn Thr Al a Tyr
 65 70 75 80

Met Gl n Leu Asn Ser Leu Thr Ser Gl u Asp Ser Al a Val Tyr Tyr Cys
 85 90 95

Al a Arg Ser Gl y Arg Leu Tyr Phe Asp Val Trp Gl y Al a Gl y Thr Thr
 100 105 110

Val Thr Val Ser Ser
 115

<210> 4
<211> 111
<212> PRT
<213> Artificial Sequence

<220>
<223> sequence of 5D5A5 VL

<400> 4

Asp Ile Val Leu Thr Gln Ser Pro Pro Ser Leu Ala Val Ser Leu Gly
1 5 10 15

Gln Arg Ala Thr Ile Ser Cys Arg Ala Ser Glu Ser Ile Asp Leu Tyr
20 25 30

Gly Phe Thr Phe Met His Trp Tyr Gln Gln Lys Pro Gly Gln Pro Pro
35 40 45

Lys Ile Leu Ile Tyr Arg Ala Ser Asn Leu Glu Ser Gly Ile Pro Ala
50 55 60

Arg Phe Ser Gly Ser Gly Ser Arg Thr Asp Phe Thr Leu Thr Ile Asn
65 70 75 80

Pro Val Glu Ala Asp Asp Val Ala Thr Tyr Tyr Cys Gln Gln Thr His
85 90 95

Gl u Asp Pro Tyr Thr Phe Gly Gly Thr Lys Leu Gl u Ile Lys
100 105 110

<210> 5
<211> 234
<212> PRT
<213> Artificial Sequence

<220>
<223> hinge-CH2CH3 of human IgG1

<400> 5

Ala Glu Pro Lys Ser Pro Asp Lys Thr His Thr Cys Pro Pro Cys Pro
1 5 10 15

Ala Pro Pro Val Ala Gly Pro Ser Val Phe Leu Phe Pro Pro Lys Pro
20 25 30

Lys Asp Thr Leu Met Ile Ala Arg Thr Pro Glu Val Thr Cys Val Val
35 40 45

Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe Asn Trp Tyr Val
50 55 60

Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro Arg Glu Glu Gln
65 70 75 80

pctgb2016052563-seqI

Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr Val Leu His Glu
85 90 95

Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val Ser Asn Lys Ala
100 105 110

Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala Lys Gly Glu Pro
115 120 125

Arg Glu Pro Glu Val Tyr Thr Leu Pro Pro Ser Arg Asp Glu Leu Thr
130 135 140

Lys Asn Glu Val Ser Leu Thr Cys Leu Val Lys Gly Phe Tyr Pro Ser
145 150 155 160

Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Glu Pro Glu Asn Asn Tyr
165 170 175

Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser Phe Phe Leu Tyr
180 185 190

Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Glu Glu Glu Asn Val Phe
195 200 205

Ser Cys Ser Val Met His Glu Ala Leu His Asn His Tyr Thr Glu Lys
210 215 220

Ser Leu Ser Leu Ser Pro Gly Lys Lys Asp
225 230

<210> 6
<211> 46
<212> PRT
<213> Artificial Sequence

<220>
<223> human CD8 stalk

<400> 6

Thr Thr Thr Pro Ala Pro Arg Pro Pro Thr Pro Ala Pro Thr Ile Ala
1 5 10 15

Ser Glu Pro Leu Ser Leu Arg Pro Glu Ala Cys Arg Pro Ala Ala Gly
20 25 30

Gly Ala Val His Thr Arg Gly Leu Asp Phe Ala Cys Asp Ile
35 40 45

<210> 7
<211> 20
<212> PRT
<213> Artificial Sequence

pctgb2016052563-seqI

<220>

<223> human IgG1 hinge

<400> 7

Ala Glu Pro Lys Ser Pro Asp Lys Thr His Thr Cys Pro Pro Cys Pro
1 5 10 15

Lys Asp Pro Lys
20

<210> 8

<211> 57

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Kinesin motor protein: parallel homodimer)

<400> 8

Met His Ala Ala Leu Ser Thr Glu Val Val His Leu Arg Glu Arg Thr
1 5 10 15

Gl u Gl u Leu Leu Arg Cys Asn Gl u Gl n Gl n Ala Ala Gl u Leu Gl u Thr
20 25 30

Cys Lys Gl u Gl n Leu Phe Gl n Ser Asn Met Gl u Arg Lys Gl u Leu His
35 40 45

Asn Thr Val Met Asp Leu Arg Gl y Asn
50 55

<210> 9

<211> 50

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Hepatitis D delta antigen: parallel homodimer)

<400> 9

Gl y Arg Gl u Asp Ile Leu Gl u Gl n Trp Val Ser Gl y Arg Lys Lys Leu
1 5 10 15

Gl u Gl u Leu Gl u Arg Asp Leu Arg Lys Leu Lys Lys Lys Ile Lys Lys
20 25 30

Leu Gl u Gl u Asp Asn Pro Trp Leu Gl y Asn Ile Lys Gl y Ile Ile Gl y
35 40 45

Lys Tyr
50

<210> 10

pctgb2016052563-seq1

<211> 61

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Archaeal box C/D sRNP core protein: anti-parallel heterodimer)

<400> 10

Arg Tyr Val Val Ala Leu Val Lys Ala Leu Glu Glu Ile Asp Glu Ser
1 5 10 15

Ile Asn Met Leu Asn Glu Lys Leu Glu Asp Ile Arg Ala Val Lys Glu
20 25 30

Ser Glu Ile Thr Glu Lys Phe Glu Lys Lys Ile Arg Glu Leu Arg Glu
35 40 45

Leu Arg Arg Asp Val Glu Arg Glu Ile Glu Glu Val Met
50 55 60

<210> 11

<211> 31

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Mannose-binding protein A: parallel homotrimer)

<400> 11

Ala Ile Glu Val Lys Leu Ala Asn Met Glu Ala Glu Ile Asn Thr Leu
1 5 10 15

Lys Ser Lys Leu Glu Leu Thr Asn Lys Leu His Ala Phe Ser Met
20 25 30

<210> 12

<211> 29

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Coiled-coil serine-rich protein 1: parallel homotrimer)

<400> 12

Gl u Trp Gl u Ala Leu Gl u Lys Lys Leu Al a Al a Leu Gl u Ser Lys Leu
1 5 10 15

Gl n Al a Leu Gl u Lys Lys Leu Gl u Al a Leu Gl u His Gl y
20 25

<210> 13

<211> 24

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Polypeptide release factor 2: anti-parallel heterotrimer Chain A)

<400> 13

Ile Asn Pro Val Asn Asn Arg Ile Gln Asp Leu Thr Glu Arg Ser Asp
1 5 10 15

Val Leu Arg Gly Tyr Leu Asp Tyr
20

<210> 14

<211> 51

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Polypeptide release factor 2: anti-parallel heterotrimer Chain B)

<400> 14

Val Val Asp Thr Leu Asp Gln Met Lys Gln Gly Leu Glu Asp Val Ser
1 5 10 15

Gly Leu Leu Gln Leu Ala Val Gln Ala Asp Asp Gln Gln Thr Phe Asn
20 25 30

Glu Ala Val Ala Glu Leu Asp Ala Leu Glu Glu Lys Leu Ala Gln Leu
35 40 45

Glu Phe Arg
50

<210> 15

<211> 51

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (SNAP-25 and SNARE: parallel heterotetramer Chain A)

<400> 15

Ile Glu Thr Arg His Ser Glu Ile Ile Lys Leu Glu Asn Ser Ile Arg
1 5 10 15

Glu Leu His Asp Met Phe Met Asp Met Ala Met Leu Val Gln Ser Gln
20 25 30

Gly Glu Met Ile Asp Arg Ile Glu Tyr Asn Val Glu His Ala Val Asp
35 40 45

Tyr Val Glu
50

<210> 16
<211> 67
<212> PRT
<213> Artificial Sequence

<220>
<223> sequence of coiled coil domain (SNAP-25 and SNARE: parallel heterotetramer Chain B)

<400> 16

Ala Leu Ser Glu Ile Glu Thr Arg His Ser Glu Ile Ile Lys Leu Glu
1 5 10 15

Asn Ser Ile Arg Glu Leu His Asp Met Phe Met Asp Met Ala Met Leu
20 25 30

Val Glu Ser Gln Gly Glu Met Ile Asp Arg Ile Glu Tyr Asn Val Glu
35 40 45

His Ala Val Asp Tyr Val Glu Arg Ala Val Ser Asp Thr Lys Lys Ala
50 55 60

Val Lys Tyr
65

<210> 17
<211> 69
<212> PRT
<213> Artificial Sequence

<220>
<223> sequence of coiled coil domain (Chain C)

<400> 17

Gl u Leu Gl u Gl u Met Gln Arg Arg Ala Asp Gl n Leu Ala Asp Gl u Ser
1 5 10 15

Leu Gl u Ser Thr Arg Arg Met Leu Gl n Leu Val Gl u Gl u Ser Lys Asp
20 25 30

Ala Gly Ile Arg Thr Leu Val Met Leu Asp Gl u Gln Gly Gl u Gln Leu
35 40 45

Gl u Arg Ile Gl u Gl u Gl y Met Asp Gl n Ile Asn Lys Asp Met Lys Gl u
50 55 60

Ala Gl u Lys Asn Leu
65

<210> 18
<211> 51
<212> PRT
<213> Artificial Sequence

<220>

pctgb2016052563-seq1
<223> sequence of coiled coil domain (SNAP-25 and SNARE: parallel heterotetramer Chain D)

<400> 18

Ile Glu Thr Arg His Ser Glu Ile Ile Lys Leu Glu Asn Ser Ile Arg
1 5 10 15

Gl u Leu His Asp Met Phe Met Asp Met Ala Met Leu Val Gl u Ser Gl n
20 25 30

Gly Glu Met Ile Asp Arg Ile Glu Tyr Asn Val Gl u His Ala Val Asp
35 40 45

Tyr Val Gl u
50

<210> 19

<211> 20

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Lac repressor: parallel homotetramer)

<400> 19

Ser Pro Arg Ala Leu Ala Asp Ser Leu Met Gl n Leu Ala Arg Gl n Val
1 5 10 15

Ser Arg Leu Gl u
20

<210> 20

<211> 136

<212> PRT

<213> Artificial Sequence

<220>

<223> sequence of coiled coil domain (Apolipoprotein E: anti-parallel heterotetramer)

<400> 20

Ser Gly Gl n Arg Trp Gl u Leu Ala Leu Gl y Arg Phe Trp Asp Tyr Leu
1 5 10 15

Arg Trp Val Gl n Thr Leu Ser Gl u Gl n Val Gl n Gl u Gl u Leu Leu Ser
20 25 30

Ser Gl n Val Thr Gl n Gl u Leu Arg Ala Leu Met Asp Gl u Thr Met Lys
35 40 45

Gl u Leu Lys Ala Tyr Lys Ser Gl u Leu Gl u Gl u Gl n Leu Thr Ala Arg
50 55 60

Leu Ser Lys Gl u Leu Gl n Ala Ala Gl n Ala Arg Leu Gl y Ala Asp Met
Page 9

65

70

75

80

Gl u Asp Val Cys Gl y Arg Leu Val Gl n Tyr Arg Gl y Gl u Val Gl n Al a
 85 90 95

Met Leu Gl y Gl n Ser Thr Gl u Gl u Leu Arg Val Arg Leu Al a Ser His
 100 105 110

Leu Arg Lys Leu Arg Lys Arg Leu Leu Arg Asp Al a Asp Asp Leu Gl n
 115 120 125

Lys Arg Leu Al a Val Tyr Gl n Al a
 130 135

<210> 21
 <211> 45
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> COMP coiled-coil domain

<400> 21

Asp Leu Gl y Pro Gl n Met Leu Arg Gl u Leu Gl n Gl u Thr Asn Al a Al a
 1 5 10 15

Leu Gl n Asp Val Arg Gl u Leu Leu Arg Gl n Gl n Val Arg Gl u Ile Thr
 20 25 30

Phe Leu Lys Asn Thr Val Met Gl u Cys Asp Al a Cys Gl y
 35 40 45

<210> 22
 <211> 21
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> signal peptide derived from TCR beta chain

<400> 22

Met Gl y Thr Ser Leu Leu Cys Trp Met Al a Leu Cys Leu Leu Gl y Al a
 1 5 10 15

Asp His Al a Asp Gl y
 20

<210> 23
 <211> 21
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> signal peptide derived from IgG1

<400> 23

pctgb2016052563-seql

Met Ser Leu Pro Val Thr Ala Leu Leu Leu Pro Leu Ala Leu Leu Leu
1 5 10 15

His Ala Ala Arg Pro
20

<210> 24
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> signal peptide derived from CD8a

<400> 24

Met Ala Val Pro Thr Gln Val Leu Gly Leu Leu Leu Leu Trp Leu Thr
1 5 10 15

Asp Ala Arg Cys
20

<210> 25
<211> 112
<212> PRT
<213> Artificial Sequence

<220>
<223> CD3 Z endodomain

<400> 25

Arg Val Lys Phe Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly
1 5 10 15

Gln Asn Gln Leu Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr
20 25 30

Asp Val Leu Asp Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys
35 40 45

Pro Arg Arg Lys Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys
50 55 60

Asp Lys Met Ala Glu Ala Tyr Ser Glu Ile Gly Met Lys Gly Glu Arg
65 70 75 80

Arg Arg Gly Lys Gly His Asp Gly Leu Tyr Gln Gly Leu Ser Thr Ala
85 90 95

Thr Lys Asp Thr Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
100 105 110

<210> 26
<211> 152
<212> PRT

pctgb2016052563-seq1

<213> Artificial Sequence

<220>

<223> CD28 and CD3 Zeta endodomains

<400> 26

Ser Lys Arg Ser Arg Leu Leu His Ser Asp Tyr Met Asn Met Thr Pro
1 5 10 15

Arg Arg Pro Gly Pro Thr Arg Lys His Tyr Glu Pro Tyr Ala Pro Pro
20 25 30

Arg Asp Phe Ala Ala Tyr Arg Ser Arg Val Lys Phe Ser Arg Ser Ala
35 40 45

Asp Ala Pro Ala Tyr Glu Glu Gly Glu Asn Glu Leu Tyr Asn Glu Leu
50 55 60

Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp Lys Arg Arg Gly
65 70 75 80

Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys Asn Pro Glu Glu
85 90 95

Gly Leu Tyr Asn Glu Leu Glu Lys Asp Lys Met Ala Glu Ala Tyr Ser
100 105 110

Glu Ile Gly Met Lys Gly Glu Arg Arg Arg Gly Lys Gly His Asp Gly
115 120 125

Leu Tyr Glu Gly Leu Ser Thr Ala Thr Lys Asp Thr Tyr Asp Ala Leu
130 135 140

His Met Glu Ala Leu Pro Pro Arg
145 150

<210> 27

<211> 188

<212> PRT

<213> Artificial Sequence

<220>

<223> CD28, OX40 and CD3 Zeta endodomains

<400> 27

Ser Lys Arg Ser Arg Leu Leu His Ser Asp Tyr Met Asn Met Thr Pro
1 5 10 15

Arg Arg Pro Gly Pro Thr Arg Lys His Tyr Glu Pro Tyr Ala Pro Pro
20 25 30

Arg Asp Phe Ala Ala Tyr Arg Ser Arg Asp Glu Arg Leu Pro Pro Asp
35 40 45

pctgb2016052563-seqI

Ala His Lys Pro Pro Gly Gly Ser Phe Arg Thr Pro Ile Gln Glu
50 55 60

Glu Gln Ala Asp Ala His Ser Thr Leu Ala Lys Ile Arg Val Lys Phe
65 70 75 80

Ser Arg Ser Ala Asp Ala Pro Ala Tyr Gln Gln Gly Gln Asn Gln Leu
85 90 95

Tyr Asn Glu Leu Asn Leu Gly Arg Arg Glu Glu Tyr Asp Val Leu Asp
100 105 110

Lys Arg Arg Gly Arg Asp Pro Glu Met Gly Gly Lys Pro Arg Arg Lys
115 120 125

Asn Pro Gln Glu Gly Leu Tyr Asn Glu Leu Gln Lys Asp Lys Met Ala
130 135 140

Gl u Ala Tyr Ser Glu Ile Gly Met Lys Gl y Gl u Arg Arg Arg Gl y Lys
145 150 155 160

Gl y His Asp Gl y Leu Tyr Gln Gl y Leu Ser Thr Ala Thr Lys Asp Thr
165 170 175

Tyr Asp Ala Leu His Met Gln Ala Leu Pro Pro Arg
180 185

<210> 28

<211> 38

<212> PRT

<213> Artificial Sequence

<220>

<223> ICOS endodomai n

<400> 28

Cys Trp Leu Thr Lys Lys Tyr Ser Ser Ser Val His Asp Pro Asn
1 5 10 15

Gly Glu Tyr Met Phe Met Arg Ala Val Asn Thr Ala Lys Lys Ser Arg
20 25 30

Leu Thr Asp Val Thr Leu
35

<210> 29

<211> 48

<212> PRT

<213> Artificial Sequence

<220>

<223> CD27 endodomai n

<400> 29

pctgb2016052563-seql

Gl n Arg Arg Lys Tyr Arg Ser Asn Lys Gl y Gl u Ser Pro Val Gl u Pro
1 5 10 15

Al a Gl u Pro Cys His Tyr Ser Cys Pro Arg Gl u Gl u Gl u Gl y Ser Thr
20 25 30

Ile Pro Ile Gl n Gl u Asp Tyr Arg Lys Pro Gl u Pro Al a Cys Ser Pro
35 40 45

<210> 30

<211> 111

<212> PRT

<213> Artificial Sequence

<220>

<223> BTLA endodomai n

<400> 30

Arg Arg His Gl n Gl y Lys Gl n Asn Gl u Leu Ser Asp Thr Al a Gl y Arg
1 5 10 15

Gl u Ile Asn Leu Val Asp Al a His Leu Lys Ser Gl u Gl n Thr Gl u Al a
20 25 30

Ser Thr Arg Gl n Asn Ser Gl n Val Leu Leu Ser Gl u Thr Gl y Ile Tyr
35 40 45

Asp Asn Asp Pro Asp Leu Cys Phe Arg Met Gl n Gl u Gl y Ser Gl u Val
50 55 60

Tyr Ser Asn Pro Cys Leu Gl u Gl u Asn Lys Pro Gl y Ile Val Tyr Al a
65 70 75 80

Ser Leu Asn His Ser Val Ile Gl y Pro Asn Ser Arg Leu Al a Arg Asn
85 90 95

Val Lys Gl u Al a Pro Thr Gl u Tyr Al a Ser Ile Cys Val Arg Ser
100 105 110

<210> 31

<211> 188

<212> PRT

<213> Artificial Sequence

<220>

<223> CD30 endodomai n

<400> 31

His Arg Arg Al a Cys Arg Lys Arg Ile Arg Gl n Lys Leu His Leu Cys
1 5 10 15

Tyr Pro Val Gl n Thr Ser Gl n Pro Lys Leu Gl u Leu Val Asp Ser Arg
20 25 30

pctgb2016052563-seqI

Pro Arg Arg Ser Ser Thr Glu Leu Arg Ser Gly Ala Ser Val Thr Glu
35 40 45

Pro Val Ala Glu Glu Arg Gly Leu Met Ser Glu Pro Leu Met Glu Thr
50 55 60

Cys His Ser Val Gly Ala Ala Tyr Leu Glu Ser Leu Pro Leu Glu Asp
65 70 75 80

Ala Ser Pro Ala Gly Gly Pro Ser Ser Pro Arg Asp Leu Pro Glu Pro
85 90 95

Arg Val Ser Thr Glu His Thr Asn Asn Lys Ile Glu Lys Ile Tyr Ile
100 105 110

Met Lys Ala Asp Thr Val Ile Val Glu Thr Val Lys Ala Glu Leu Pro
115 120 125

Gl u Gl y Arg Gl y Leu Ala Gl y Pro Ala Gl u Pro Gl u Leu Gl u Gl u Gl u
130 135 140

Leu Gl u Ala Asp His Thr Pro His Tyr Pro Gl u Gl n Gl u Thr Gl u Pro
145 150 155 160

Pro Leu Gl y Ser Cys Ser Asp Val Met Leu Ser Val Gl u Gl u Gl u Gl y
165 170 175

Lys Gl u Asp Pro Leu Pro Thr Ala Ala Ser Gl y Lys
180 185

<210> 32

<211> 58

<212> PRT

<213> Artificial Sequence

<220>

<223> GI TR endodomai n

<400> 32

Gl n Leu Gl y Leu His Ile Trp Gl n Leu Arg Ser Gl n Cys Met Trp Pro
1 5 10 15

Arg Gl u Thr Gl n Leu Leu Leu Gl u Val Pro Pro Ser Thr Gl u Asp Ala
20 25 30

Arg Ser Cys Gl n Phe Pro Gl u Gl u Gl u Arg Gl y Gl u Arg Ser Ala Gl u
35 40 45

Gl u Lys Gl y Arg Leu Gl y Asp Leu Trp Val
50 55

<210> 33

pctgb2016052563-seqI

<211> 60
<212> PRT
<213> Artificial Sequence

<220>
<223> HVEM endodomain

<400> 33

Cys Val Lys Arg Arg Lys Pro Arg Gly Asp Val Val Lys Val Ile Val
1 5 10 15

Ser Val Gln Arg Lys Arg Gln Glu Ala Glu Gly Glu Ala Thr Val Ile
20 25 30

Gl u Ala Leu Gln Ala Pro Pro Asp Val Thr Thr Val Ala Val Glu Glu
35 40 45

Thr Ile Pro Ser Phe Thr Gly Arg Ser Pro Asn His
50 55 60

<210> 34
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> cleavage site, 2A-like sequence

<400> 34

Tyr His Ala Asp Tyr Tyr Lys Gln Arg Leu Ile His Asp Val Glu Met
1 5 10 15

Asn Pro Gly Pro
20

<210> 35
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> cleavage site, 2A-like sequence

<400> 35

His Tyr Ala Gly Tyr Phe Ala Asp Leu Leu Ile His Asp Ile Glu Thr
1 5 10 15

Asn Pro Gly Pro
20

<210> 36
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> cleavage site, 2A-like sequence

<400> 36

Gl n Cys Thr Asn Tyr Al a Leu Leu Lys Leu Al a Gl y Asp Val Gl u Ser
1 5 10 15

Asn Pro Gl y Pro
20

<210> 37

<211> 19

<212> PRT

<213> Arti fici al Sequence

<220>

<223> cleavage si te, 2A-lik e sequence

<400> 37

Al a Thr Asn Phe Ser Leu Leu Lys Gl n Al a Gl y Asp Val Gl u Gl u Asn
1 5 10 15

Pro Gl y Pro

<210> 38

<211> 19

<212> PRT

<213> Arti fici al Sequence

<220>

<223> cleavage si te, 2A-lik e sequence

<400> 38

Al a Al a Arg Gl n Met Leu Leu Leu Leu Ser Gl y Asp Val Gl u Thr Asn
1 5 10 15

Pro Gl y Pro

<210> 39

<211> 20

<212> PRT

<213> Arti fici al Sequence

<220>

<223> cleavage si te, 2A-lik e sequence

<400> 39

Arg Al a Gl u Gl y Arg Gl y Ser Leu Leu Thr Cys Gl y Asp Val Gl u Gl u
1 5 10 15

Asn Pro Gl y Pro
20

<210> 40

<211> 20

<212> PRT

pctgb2016052563-seql

<213> Artificial Sequence

<220>

<223> cleavage site, 2A-like sequence

<400> 40

Thr Arg Ala Glu Ile Glu Asp Glu Leu Ile Arg Ala Gly Ile Glu Ser
1 5 10 15

Asn Pro Gly Pro
20

<210> 41

<211> 20

<212> PRT

<213> Artificial Sequence

<220>

<223> cleavage site, 2A-like sequence

<400> 41

Thr Arg Ala Glu Ile Glu Asp Glu Leu Ile Arg Ala Asp Ile Glu Ser
1 5 10 15

Asn Pro Gly Pro
20

<210> 42

<211> 20

<212> PRT

<213> Artificial Sequence

<220>

<223> cleavage site, 2A-like sequence

<400> 42

Ala Lys Phe Gln Ile Asp Lys Ile Leu Ile Ser Gly Asp Val Glu Leu
1 5 10 15

Asn Pro Gly Pro
20

<210> 43

<211> 20

<212> PRT

<213> Artificial Sequence

<220>

<223> cleavage site, 2A-like sequence

<400> 43

Ser Ser Ile Ile Arg Thr Lys Met Leu Val Ser Gly Asp Val Glu Glu
1 5 10 15

Asn Pro Gly Pro
20

pctgb2016052563-seql

<210> 44
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> cleavage site, 2A-like sequence

<400> 44

Cys Asp Ala Glu Arg Glu Lys Leu Leu Leu Ser Gly Asp Ile Glu Glu
1 5 10 15

Asn Pro Gly Pro
20

<210> 45
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> cleavage site, 2A-like sequence

<400> 45

Tyr Pro Ile Asp Phe Gly Gly Phe Leu Val Lys Ala Asp Ser Glu Phe
1 5 10 15

Asn Pro Gly Pro
20

<210> 46
<211> 595
<212> PRT
<213> Artificial Sequence

<220>
<223> inhibitor domain, PTPN6

<400> 46

Met Val Arg Trp Phe His Arg Asp Leu Ser Gly Leu Asp Ala Glu Thr
1 5 10 15

Leu Leu Lys Gly Arg Gly Val His Gly Ser Phe Leu Ala Arg Pro Ser
20 25 30

Arg Lys Asn Glu Gly Asp Phe Ser Leu Ser Val Arg Val Gly Asp Glu
35 40 45

Val Thr His Ile Arg Ile Glu Asn Ser Gly Asp Phe Tyr Asp Leu Tyr
50 55 60

Gly Gly Glu Lys Phe Ala Thr Leu Thr Glu Leu Val Glu Tyr Tyr Thr
65 70 75 80

Glu Glu Glu Glu Val Leu Glu Asp Arg Asp Gly Thr Ile Ile His Leu
Page 19

pctgb2016052563-seqI

85

90

95

Lys Tyr Pro Leu Asn Cys Ser Asp Pro Thr Ser Glu Arg Trp Tyr His
 100 105 110

Gly His Met Ser Gly Gly Gln Ala Glu Thr Leu Leu Gln Ala Lys Gly
 115 120 125

Glu Pro Trp Thr Phe Leu Val Arg Glu Ser Leu Ser Gln Pro Gly Asp
 130 135 140

Phe Val Leu Ser Val Leu Ser Asp Gln Pro Lys Ala Gly Pro Gly Ser
 145 150 155 160

Pro Leu Arg Val Thr His Ile Lys Val Met Cys Glu Gly Gly Arg Tyr
 165 170 175

Thr Val Gly Gly Leu Glu Thr Phe Asp Ser Leu Thr Asp Leu Val Glu
 180 185 190

His Phe Lys Lys Thr Gly Ile Glu Glu Ala Ser Gly Ala Phe Val Tyr
 195 200 205

Leu Arg Gln Pro Tyr Tyr Ala Thr Arg Val Asn Ala Ala Asp Ile Glu
 210 215 220

Asn Arg Val Leu Glu Leu Asn Lys Lys Gln Glu Ser Glu Asp Thr Ala
 225 230 235 240

Lys Ala Gly Phe Trp Glu Glu Phe Glu Ser Leu Gln Lys Gln Glu Val
 245 250 255

Lys Asn Leu His Gln Arg Leu Glu Gly Gln Arg Pro Glu Asn Lys Gly
 260 265 270

Lys Asn Arg Tyr Lys Asn Ile Leu Pro Phe Asp His Ser Arg Val Ile
 275 280 285

Leu Gln Gly Arg Asp Ser Asn Ile Pro Gln Ser Asp Tyr Ile Asn Ala
 290 295 300

Asn Tyr Ile Lys Asn Gln Leu Leu Gly Pro Asp Glu Asn Ala Lys Thr
 305 310 315 320

Tyr Ile Ala Ser Gln Gly Cys Leu Glu Ala Thr Val Asn Asp Phe Trp
 325 330 335

Gln Met Ala Trp Gln Glu Asn Ser Arg Val Ile Val Met Thr Thr Arg
 340 345 350

Glu Val Glu Lys Gly Arg Asn Lys Cys Val Pro Tyr Trp Pro Glu Val
 Page 20

pctgb2016052563-seq1
 355 360 365
 Gly Met Glu Arg Ala Tyr Gly Pro Tyr Ser Val Thr Asn Cys Gly Glu
 370 375 380
 His Asp Thr Thr Glu Tyr Lys Leu Arg Thr Leu Glu Val Ser Pro Leu
 385 390 395 400
 Asp Asn Gly Asp Leu Ile Arg Glu Ile Trp His Tyr Glu Tyr Leu Ser
 405 410 415
 Trp Pro Asp His Gly Val Pro Ser Glu Pro Gly Gly Val Leu Ser Phe
 420 425 430
 Leu Asp Glu Ile Asn Glu Arg Glu Glu Ser Leu Pro His Ala Gly Pro
 435 440 445
 Ile Ile Val His Cys Ser Ala Gly Ile Gly Arg Thr Gly Thr Ile Ile
 450 455 460
 Val Ile Asp Met Leu Met Glu Asn Ile Ser Thr Lys Gly Leu Asp Cys
 465 470 475 480
 Asp Ile Asp Ile Glu Lys Thr Ile Glu Met Val Arg Ala Glu Arg Ser
 485 490 495
 Gly Met Val Glu Thr Glu Ala Glu Tyr Lys Phe Ile Tyr Val Ala Ile
 500 505 510
 Ala Glu Phe Ile Glu Thr Thr Lys Lys Lys Leu Glu Val Leu Glu Ser
 515 520 525
 Glu Lys Gly Glu Glu Ser Glu Tyr Gly Asn Ile Thr Tyr Pro Pro Ala
 530 535 540
 Met Lys Asn Ala His Ala Lys Ala Ser Arg Thr Ser Ser Lys His Lys
 545 550 555 560
 Glu Asp Val Tyr Glu Asn Leu His Thr Lys Asn Lys Arg Glu Glu Lys
 565 570 575
 Val Lys Lys Glu Arg Ser Ala Asp Lys Glu Lys Ser Lys Glu Ser Leu
 580 585 590
 Lys Arg Lys
 595

<210> 47
<211> 272
<212> PRT
<213> Artificial Sequence

pctgb2016052563-seqI

<220>

<223> inhibitor domain, phosphatase domain of PTPN6

<400> 47

Phe Trp Glu Glu Phe Glu Ser Leu Glu Lys Glu Glu Val Lys Asn Leu
1 5 10 15

His Glu Arg Leu Glu Gly Glu Arg Pro Glu Asn Lys Gly Lys Asn Arg
20 25 30

Tyr Lys Asn Ile Leu Pro Phe Asp His Ser Arg Val Ile Leu Glu Gly
35 40 45

Arg Asp Ser Asn Ile Pro Gly Ser Asp Tyr Ile Asn Ala Asn Tyr Ile
50 55 60

Lys Asn Glu Leu Leu Gly Pro Asp Glu Asn Ala Lys Thr Tyr Ile Ala
65 70 75 80

Ser Glu Gly Cys Leu Glu Ala Thr Val Asn Asp Phe Trp Glu Met Ala
85 90 95

Trp Glu Glu Asn Ser Arg Val Ile Val Met Thr Thr Arg Glu Val Glu
100 105 110

Lys Gly Arg Asn Lys Cys Val Pro Tyr Trp Pro Glu Val Gly Met Glu
115 120 125

Arg Ala Tyr Gly Pro Tyr Ser Val Thr Asn Cys Gly Glu His Asp Thr
130 135 140

Thr Glu Tyr Lys Leu Arg Thr Leu Glu Val Ser Pro Leu Asp Asn Gly
145 150 155 160

Asp Leu Ile Arg Glu Ile Trp His Tyr Glu Tyr Leu Ser Trp Pro Asp
165 170 175

His Gly Val Pro Ser Glu Pro Gly Gly Val Leu Ser Phe Leu Asp Glu
180 185 190

Ile Asn Glu Arg Glu Glu Ser Leu Pro His Ala Gly Pro Ile Ile Val
195 200 205

His Cys Ser Ala Gly Ile Gly Arg Thr Gly Thr Ile Ile Val Ile Asp
210 215 220

Met Leu Met Glu Asn Ile Ser Thr Lys Gly Leu Asp Cys Asp Ile Asp
225 230 235 240

Ile Glu Lys Thr Ile Glu Met Val Arg Ala Glu Arg Ser Gly Met Val
245 250 255

pctgb2016052563-seql

Gl n Thr Gl u Al a Gl n Tyr Lys Phe Ile Tyr Val Al a Ile Al a Gl n Phe
260 265 270

<210> 48
<211> 97
<212> PRT
<213> Artificial Sequence

<220>
<223> PDCD1 endodomai n

<400> 48

Cys Ser Arg Al a Al a Arg Gl y Thr Ile Gl y Al a Arg Arg Thr Gl y Gl n
1 5 10 15

Pro Leu Lys Gl u Asp Pro Ser Al a Val Pro Val Phe Ser Val Asp Tyr
20 25 30

Gl y Gl u Leu Asp Phe Gl n Trp Arg Gl u Lys Thr Pro Gl u Pro Pro Val
35 40 45

Pro Cys Val Pro Gl u Gl n Thr Gl u Tyr Al a Thr Ile Val Phe Pro Ser
50 55 60

Gl y Met Gl y Thr Ser Ser Pro Al a Arg Arg Gl y Ser Al a Asp Gl y Pro
65 70 75 80

Arg Ser Al a Gl n Pro Leu Arg Pro Gl u Asp Gl y His Cys Ser Trp Pro
85 90 95

Leu

<210> 49
<211> 141
<212> PRT
<213> Artificial Sequence

<220>
<223> BTLA4 endodomai n

<400> 49

Lys Leu Gl n Arg Arg Trp Lys Arg Thr Gl n Ser Gl n Gl n Gl y Leu Gl n
1 5 10 15

Gl u Asn Ser Ser Gl y Gl n Ser Phe Phe Val Arg Asn Lys Lys Val Arg
20 25 30

Arg Al a Pro Leu Ser Gl u Gl y Pro His Ser Leu Gl y Cys Tyr Asn Pro
35 40 45

Met Met Gl u Asp Gl y Ile Ser Tyr Thr Thr Leu Arg Phe Pro Gl u Met
50 55 60

pctgb2016052563-seqI

Asn Ile Pro Arg Thr Gly Asp Ala Glu Ser Ser Glu Met Glu Arg Pro
65 70 75 80

Pro Pro Asp Cys Asp Asp Thr Val Thr Tyr Ser Ala Leu His Lys Arg
85 90 95

Gln Val Gly Asp Tyr Glu Asn Val Ile Pro Asp Phe Pro Glu Asp Glu
100 105 110

Gly Ile His Tyr Ser Glu Leu Ile Gln Phe Gly Val Gly Glu Arg Pro
115 120 125

Gln Ala Gln Glu Asn Val Asp Tyr Val Ile Leu Lys His
130 135 140

<210> 50

<211> 168

<212> PRT

<213> Artificial Sequence

<220>

<223> LI LRB1 endodomain

<400> 50

Leu Arg His Arg Arg Gln Gly Lys His Trp Thr Ser Thr Gln Arg Lys
1 5 10 15

Ala Asp Phe Gln His Pro Ala Gly Ala Val Gly Pro Glu Pro Thr Asp
20 25 30

Arg Gly Leu Gln Trp Arg Ser Ser Pro Ala Ala Asp Ala Gln Glu Glu
35 40 45

Asn Leu Tyr Ala Ala Val Lys His Thr Gln Pro Glu Asp Gly Val Glu
50 55 60

Met Asp Thr Arg Ser Pro His Asp Glu Asp Pro Gln Ala Val Thr Tyr
65 70 75 80

Ala Glu Val Lys His Ser Arg Pro Arg Arg Glu Met Ala Ser Pro Pro
85 90 95

Ser Pro Leu Ser Gly Glu Phe Leu Asp Thr Lys Asp Arg Gln Ala Glu
100 105 110

Glu Asp Arg Gln Met Asp Thr Glu Ala Ala Ala Ser Glu Ala Pro Gln
115 120 125

Asp Val Thr Tyr Ala Gln Leu His Ser Leu Thr Leu Arg Arg Glu Ala
130 135 140

Thr Glu Pro Pro Pro Ser Gln Glu Gly Pro Ser Pro Ala Val Pro Ser
Page 24

145

150

155

160

Ile Tyr Ala Thr Leu Ala Ile His
 165

<210> 51
 <211> 101
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> LAI R1 endodomai n

<400> 51

His Arg Gln Asn Gln Ile Lys Gln Gly Pro Pro Arg Ser Lys Asp Glu
 1 5 10 15

Gl u Gln Lys Pro Gln Gln Arg Pro Asp Leu Ala Val Asp Val Leu Gl u
 20 25 30

Arg Thr Ala Asp Lys Ala Thr Val Asn Gly Leu Pro Gl u Lys Asp Arg
 35 40 45

Gl u Thr Asp Thr Ser Ala Leu Ala Ala Gly Ser Ser Gln Gl u Val Thr
 50 55 60

Tyr Ala Gln Leu Asp His Trp Ala Leu Thr Gln Arg Thr Ala Arg Ala
 65 70 75 80

Val Ser Pro Gln Ser Thr Lys Pro Met Ala Gl u Ser Ile Thr Tyr Ala
 85 90 95

Ala Val Ala Arg His
 100

<210> 52
 <211> 62
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> CTLA4 endodomai n

<400> 52

Phe Leu Leu Trp Ile Leu Ala Ala Val Ser Ser Gly Leu Phe Phe Tyr
 1 5 10 15

Ser Phe Leu Leu Thr Ala Val Ser Leu Ser Lys Met Leu Lys Lys Arg
 20 25 30

Ser Pro Leu Thr Thr Gly Val Tyr Val Lys Met Pro Pro Thr Gl u Pro
 35 40 45

Gl u Cys Gl u Lys Gln Phe Gln Pro Tyr Phe Ile Pro Ile Asn
 Page 25

50

55

60

<210> 53
 <211> 111
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> KIR2DL1 endodomai n

<400> 53

Gly Asn Ser Arg His Leu His Val Leu Ile Gly Thr Ser Val Val Ile
 1 5 10 15

Ile Pro Phe Ala Ile Leu Leu Phe Phe Leu Leu His Arg Trp Cys Ala
 20 25 30

Asn Lys Lys Asn Ala Val Val Met Asp Gln Glu Pro Ala Gly Asn Arg
 35 40 45

Thr Val Asn Arg Glu Asp Ser Asp Glu Gln Asp Pro Gln Glu Val Thr
 50 55 60

Tyr Thr Gln Leu Asn His Cys Val Phe Thr Gln Arg Lys Ile Thr Arg
 65 70 75 80

Pro Ser Gln Arg Pro Lys Thr Pro Pro Thr Asp Ile Ile Val Tyr Thr
 85 90 95

Gl u Leu Pro Asn Ala Glu Ser Arg Ser Lys Val Val Ser Cys Pro
 100 105 110

<210> 54
 <211> 143
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> KIR2DL4 endodomai n

<400> 54

Gly Ile Ala Arg His Leu His Ala Val Ile Arg Tyr Ser Val Ala Ile
 1 5 10 15

Ile Leu Phe Thr Ile Leu Pro Phe Phe Leu Leu His Arg Trp Cys Ser
 20 25 30

Lys Lys Lys Glu Asn Ala Ala Val Met Asn Gln Glu Pro Ala Gly His
 35 40 45

Arg Thr Val Asn Arg Glu Asp Ser Asp Glu Gln Asp Pro Gln Glu Val
 50 55 60

Thr Tyr Ala Gln Leu Asp His Cys Ile Phe Thr Gln Arg Lys Ile Thr
 Page 26

65

70

75

80

Gly Pro Ser Glu Arg Ser Lys Arg Pro Ser Thr Asp Thr Ser Val Cys
 85 90 95

Ile Glu Leu Pro Asn Ala Glu Pro Arg Ala Leu Ser Pro Ala His Glu
 100 105 110

His His Ser Glu Ala Leu Met Gly Ser Ser Arg Glu Thr Thr Ala Leu
 115 120 125

Ser Glu Thr Glu Leu Ala Ser Ser Asn Val Pro Ala Ala Gly Ile
 130 135 140

<210> 55

<211> 143

<212> PRT

<213> Artificial Sequence

<220>

<223> KIR2DL5 endodomain

<400> 55

Thr Gly Ile Arg Arg His Leu His Ile Leu Ile Gly Thr Ser Val Ala
 1 5 10 15

Ile Ile Leu Phe Ile Ile Leu Phe Phe Phe Leu Leu His Cys Cys Cys
 20 25 30

Ser Asn Lys Lys Asn Ala Ala Val Met Asp Glu Glu Pro Ala Gly Asp
 35 40 45

Arg Thr Val Asn Arg Glu Asp Ser Asp Asp Glu Asp Pro Glu Glu Val
 50 55 60

Thr Tyr Ala Glu Leu Asp His Cys Val Phe Thr Glu Thr Lys Ile Thr
 65 70 75 80

Ser Pro Ser Glu Arg Pro Lys Thr Pro Pro Thr Asp Thr Thr Met Tyr
 85 90 95

Met Glu Leu Pro Asn Ala Lys Pro Arg Ser Leu Ser Pro Ala His Lys
 100 105 110

His His Ser Glu Ala Leu Arg Gly Ser Ser Arg Glu Thr Thr Ala Leu
 115 120 125

Ser Glu Asn Arg Val Ala Ser Ser His Val Pro Ala Ala Gly Ile
 130 135 140

<210> 56

<211> 111

<212> PRT

pctgb2016052563-seqI

<213> Artificial Sequence

<220>

<223> KI R3DL1 endodomai n

<400> 56

Lys Asp Pro Arg His Leu His Ile Leu Ile Gly Thr Ser Val Val Ile
1 5 10 15

Ile Leu Phe Ile Leu Leu Leu Phe Phe Leu Leu His Leu Trp Cys Ser
20 25 30

Asn Lys Lys Asn Ala Ala Val Met Asp Gln Glu Pro Ala Gly Asn Arg
35 40 45

Thr Ala Asn Ser Glu Asp Ser Asp Glu Gln Asp Pro Glu Glu Val Thr
50 55 60

Tyr Ala Gln Leu Asp His Cys Val Phe Thr Gln Arg Lys Ile Thr Arg
65 70 75 80

Pro Ser Gln Arg Pro Lys Thr Pro Pro Thr Asp Thr Ile Leu Tyr Thr
85 90 95

Gl u Leu Pro Asn Ala Lys Pro Arg Ser Lys Val Val Ser Cys Pro
100 105 110

<210> 57

<211> 97

<212> PRT

<213> Artificial Sequence

<220>

<223> KI R3DL3 endodomai n

<400> 57

Lys Asp Pro Gly Asn Ser Arg His Leu His Val Leu Ile Gly Thr Ser
1 5 10 15

Val Val Ile Ile Pro Phe Ala Ile Leu Leu Phe Phe Leu Leu His Arg
20 25 30

Trp Cys Ala Asn Lys Lys Asn Ala Val Val Met Asp Gln Glu Pro Ala
35 40 45

Gly Asn Arg Thr Val Asn Arg Glu Asp Ser Asp Glu Gln Asp Pro Gln
50 55 60

Gl u Val Thr Tyr Ala Gln Leu Asn His Cys Val Phe Thr Gln Arg Lys
65 70 75 80

Ile Thr Arg Pro Ser Gln Arg Pro Lys Thr Pro Pro Thr Asp Thr Ser
85 90 95

Val

<210> 58
 <211> 807
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> PTPN6-CD45 fusion protein

<400> 58

Trp Tyr His Gly His Met Ser Gly Gly Glu Ala Glu Thr Leu Leu Glu
 1 5 10 15

Ala Lys Gly Glu Pro Trp Thr Phe Leu Val Arg Glu Ser Leu Ser Glu
 20 25 30

Pro Gly Asp Phe Val Leu Ser Val Leu Ser Asp Glu Pro Lys Ala Gly
 35 40 45

Pro Gly Ser Pro Leu Arg Val Thr His Ile Lys Val Met Cys Glu Gly
 50 55 60

Gly Arg Tyr Thr Val Gly Gly Leu Glu Thr Phe Asp Ser Leu Thr Asp
 65 70 75 80

Leu Val Glu His Phe Lys Lys Thr Gly Ile Glu Glu Ala Ser Gly Ala
 85 90 95

Phe Val Tyr Leu Arg Glu Pro Tyr Lys Ile Tyr Asp Leu His Lys Lys
 100 105 110

Arg Ser Cys Asn Leu Asp Glu Glu Glu Glu Leu Val Glu Arg Asp Asp
 115 120 125

Gl u Lys Gl n Leu Met Asn Val Gl u Pro Ile His Ala Asp Ile Leu Leu
 130 135 140

Gl u Thr Tyr Lys Arg Lys Ile Ala Asp Gl u Gly Arg Leu Phe Leu Ala
 145 150 155 160

Gl u Phe Gl n Ser Ile Pro Arg Val Phe Ser Lys Phe Pro Ile Lys Gl u
 165 170 175

Ala Arg Lys Pro Phe Asn Gl n Asn Lys Asn Arg Tyr Val Asp Ile Leu
 180 185 190

Pro Tyr Asp Tyr Asn Arg Val Gl u Leu Ser Gl u Ile Asn Gl y Asp Ala
 195 200 205

Gly Ser Asn Tyr Ile Asn Ala Ser Tyr Ile Asp Gl y Phe Lys Gl u Pro
 Page 29

pctgb2016052563-seql
210 215 220
Arg Lys Tyr Ile Ala Ala Glu Glu Pro Arg Asp Glu Thr Val Asp Asp
225 230 235 240
Phe Trp Arg Met Ile Trp Glu Glu Lys Ala Thr Val Ile Val Met Val
245 250 255
Thr Arg Cys Glu Glu Gly Asn Arg Asn Lys Cys Ala Glu Tyr Trp Pro
260 265 270 275
Ser Met Glu Glu Gly Thr Arg Ala Phe Gly Asp Val Val Val Lys Ile
275 280 285
Asn Glu His Lys Arg Cys Pro Asp Tyr Ile Ile Glu Lys Leu Asn Ile
290 295 300
Val Asn Lys Lys Glu Lys Ala Thr Gly Arg Glu Val Thr His Ile Glu
305 310 315 320
Phe Thr Ser Trp Pro Asp His Glu Val Pro Glu Asp Pro His Leu Leu
325 330 335
Leu Lys Leu Arg Arg Arg Val Asn Ala Phe Ser Asn Phe Phe Ser Gly
340 345 350
Pro Ile Val Val His Cys Ser Ala Glu Val Gly Arg Thr Gly Thr Tyr
355 360 365
Ile Gly Ile Asp Ala Met Leu Glu Gly Leu Glu Ala Glu Asn Lys Val
370 375 380
Asp Val Tyr Glu Tyr Val Val Lys Leu Arg Arg Glu Arg Cys Leu Met
385 390 395 400
Val Glu Val Glu Ala Glu Tyr Ile Leu Ile His Glu Ala Leu Val Glu
405 410 415
Tyr Asn Glu Phe Glu Glu Thr Glu Val Asn Leu Ser Glu Leu His Pro
420 425 430
Tyr Leu His Asn Met Lys Lys Arg Asp Pro Pro Ser Glu Pro Ser Pro
435 440 445
Leu Glu Ala Glu Phe Glu Arg Leu Pro Ser Tyr Arg Ser Trp Arg Thr
450 455 460 470
Gln His Ile Gly Asn Glu Glu Glu Asn Lys Ser Lys Asn Arg Asn Ser
465 475 480
Asn Val Ile Pro Tyr Asp Tyr Asn Arg Val Leu Lys His Glu Leu Glu

pctgb2016052563-seqI

485

490

495

Met Ser Lys Glu Ser Glu His Asp Ser Asp Glu Ser Ser Asp Asp Asp
 500 505 510

Ser Asp Ser Glu Glu Pro Ser Lys Tyr Ile Asn Ala Ser Phe Ile Met
 515 520 525

Ser Tyr Trp Lys Pro Glu Val Met Ile Ala Ala Glu Gly Pro Leu Lys
 530 535 540

Gl u Thr Ile Gly Asp Phe Met Ile Glu Arg Lys Val Lys Val Ile Val
 545 550 555 560

Met Leu Thr Glu Leu Lys His Gly Asp Glu Glu Ile Cys Ala Glu Tyr
 565 570 575

Trp Gly Glu Gly Lys Glu Thr Tyr Gly Asp Ile Glu Val Asp Leu Lys
 580 585 590

Asp Thr Asp Lys Ser Ser Thr Tyr Thr Leu Arg Val Phe Glu Leu Arg
 595 600 605

His Ser Lys Arg Lys Asp Ser Arg Thr Val Tyr Glu Tyr Glu Tyr Thr
 610 615 620

Asn Trp Ser Val Glu Glu Leu Pro Ala Glu Pro Lys Glu Leu Ile Ser
 625 630 635 640

Met Ile Glu Val Val Lys Glu Lys Leu Pro Glu Lys Asn Ser Ser Glu
 645 650 655

Gly Asn Lys His His Lys Ser Thr Pro Leu Leu Ile His Cys Arg Asp
 660 665 670

Gly Ser Glu Glu Thr Gly Ile Phe Cys Ala Leu Leu Asn Leu Leu Glu
 675 680 685

Ser Ala Glu Thr Glu Glu Val Val Asp Ile Phe Glu Val Val Lys Ala
 690 695 700

Leu Arg Lys Ala Arg Pro Gly Met Val Ser Thr Phe Glu Glu Tyr Glu
 705 710 715 720

Phe Leu Tyr Asp Val Ile Ala Ser Thr Tyr Pro Ala Glu Asn Gly Glu
 725 730 735

Val Lys Lys Asn Asn His Glu Glu Asp Lys Ile Glu Phe Asp Asn Glu
 740 745 750

Val Asp Lys Val Lys Glu Asp Ala Asn Cys Val Asn Pro Leu Gly Ala
 Page 31

pctgb2016052563-seqI
755 760 765

Pro Glu Lys Leu Pro Glu Ala Lys Glu Glu Ala Glu Glu Ser Glu Pro
770 775 780

Thr Ser Gly Thr Glu Gly Pro Glu His Ser Val Asn Gly Pro Ala Ser
785 790 795 800

Pro Ala Leu Asn Glu Gly Ser
805

<210> 59
<211> 434
<212> PRT
<213> Artificial Sequence

<220>
<223> PTPN6-CD148 fusion

<400> 59

Gl u Thr Leu Leu Gl n Ala Lys Gl y Gl u Pro Trp Thr Phe Leu Val Arg
1 5 10 15

Gl u Ser Leu Ser Gl n Pro Gl y Asp Phe Val Leu Ser Val Leu Ser Asp
20 25 30

Gl n Pro Lys Ala Gl y Pro Gl y Ser Pro Leu Arg Val Thr His Ile Lys
35 40 45

Val Met Cys Gl u Gl y Gl y Arg Tyr Thr Val Gl y Gl y Leu Gl u Thr Phe
50 55 60

Asp Ser Leu Thr Asp Leu Val Gl u His Phe Lys Lys Thr Gl y Ile Gl u
65 70 75 80

Gl u Ala Ser Gl y Ala Phe Val Tyr Leu Arg Gl n Pro Tyr Arg Lys Lys
85 90 95

Arg Lys Asp Ala Lys Asn Asn Gl u Val Ser Phe Ser Gl n Ile Lys Pro
100 105 110

Lys Lys Ser Lys Leu Ile Arg Val Gl u Asn Phe Gl u Ala Tyr Phe Lys
115 120 125

Lys Gl n Gl n Ala Asp Ser Asn Cys Gl y Phe Ala Gl u Gl u Tyr Gl u Asp
130 135 140

Leu Lys Leu Val Gl y Ile Ser Gl n Pro Lys Tyr Ala Ala Gl u Leu Ala
145 150 155 160

Gl u Asn Arg Gl y Lys Asn Arg Tyr Asn Asn Val Leu Pro Tyr Asp Ile
165 170 175

pctgb2016052563-seqI

Ser Arg Val Lys Leu Ser Val Glu Thr His Ser Thr Asp Asp Tyr Ile
180 185 190

Asn Ala Asn Tyr Met Pro Gly Tyr His Ser Lys Lys Asp Phe Ile Ala
195 200 205

Thr Glu Gly Pro Leu Pro Asn Thr Leu Lys Asp Phe Trp Arg Met Val
210 215 220

Trp Glu Lys Asn Val Tyr Ala Ile Ile Met Leu Thr Lys Cys Val Glu
225 230 235 240

Gln Gly Arg Thr Lys Cys Glu Glu Tyr Trp Pro Ser Lys Gln Ala Gln
245 250 255

Asp Tyr Gly Asp Ile Thr Val Ala Met Thr Ser Glu Ile Val Leu Pro
260 265 270

Gl u Trp Thr Ile Arg Asp Phe Thr Val Lys Asn Ile Gln Thr Ser Glu
275 280 285

Ser His Pro Leu Arg Gln Phe His Phe Thr Ser Trp Pro Asp His Glu
290 295 300

Val Pro Asp Thr Thr Asp Leu Leu Ile Asn Phe Arg Tyr Leu Val Arg
305 310 315 320

Asp Tyr Met Lys Gln Ser Pro Pro Glu Ser Pro Ile Leu Val His Cys
325 330 335

Ser Ala Glu Val Glu Arg Thr Glu Thr Phe Ile Ala Ile Asp Arg Leu
340 345 350

Ile Tyr Gln Ile Glu Asn Glu Asn Thr Val Asp Val Tyr Glu Ile Val
355 360 365

Tyr Asp Leu Arg Met His Arg Pro Leu Met Val Glu Thr Glu Asp Glu
370 375 380

Tyr Val Phe Leu Asn Gln Cys Val Leu Asp Ile Val Arg Ser Gln Lys
385 390 395 400

Asp Ser Lys Val Asp Leu Ile Tyr Gln Asn Thr Thr Ala Met Thr Ile
405 410 415

Tyr Glu Asn Leu Ala Pro Val Thr Thr Phe Glu Lys Thr Asn Glu Tyr
420 425 430

Ile Ala

<210> 60
<211> 5
<212> PRT
<213> Artificial Sequence

<220>
<223> truncated COMP coiled-coil domain

<400> 60

Cys Asp Ala Cys Glu
1 5

<210> 61
<211> 20
<212> PRT
<213> Artificial Sequence

<220>
<223> truncated COMP coiled-coil domain

<400> 61

Gln Gln Val Arg Glu Ile Thr Phe Leu Lys Asn Thr Val Met Glu Cys
1 5 10 15

Asp Ala Cys Glu
20

<210> 62
<211> 4
<212> PRT
<213> Artificial Sequence

<220>
<223> furin cleavage site

<220>
<221> misc_feature
<222> (2)..(2)
<223> Xaa can be any naturally occurring amino acid

<220>
<221> MI SC_FEATURE
<222> (3)..(3)
<223> Xaa can be Arg or Lys

<400> 62

Arg Xaa Xaa Arg
1

<210> 63
<211> 7
<212> PRT
<213> Artificial Sequence

<220>
<223> consensus Tobacco Etch Virus (TEV) cleavage site

<400> 63

Gl u Asn Leu Tyr Phe Gl n Ser
1 5

<210> 64
<211> 5
<212> PRT
<213> Artificial Sequence

<220>
<223> ITIM conserved sequence

<220>
<221> MI SC FEATURE
<222> (1)..(1)
<223> Xaa may be Ser, Ile, Val or Leu

<220>
<221> mi sc_feature
<222> (2)..(2)
<223> Xaa can be any naturally occurring amino acid

<220>
<221> mi sc_feature
<222> (4)..(5)
<223> Xaa can be any naturally occurring amino acid

<220>
<221> MI SC FEATURE
<222> (6)..(6)
<223> Xaa may be Ile, Val or Leu

<400> 64

Xaa Xaa Tyr Xaa Xaa
1 5