

GITR ANTAGONISTS AND METHODS OF USING THE SAME

[1] The disclosure relates generally to biology and medicine, and more particularly it relates to antagonists of glucocorticoid-induced TNFR-related protein (GITR), also known as tumor necrosis factor receptor superfamily member 18 (TNFRSF18), especially
5 monovalent antagonist formats that lack Fc-gamma receptor (FcγR) binding and are unable to stimulate GITR agonism. The disclosure further relates to compositions including the same and their use in treating autoimmune diseases or disorders.

[2] GITR is a member of the TNFR superfamily and is known to be expressed on various immune cells including regulatory T cells (Tregs) and activated T cells. *See, e.g.,*
10 Tian, J., et al., (2020) *Front. Immunol.*, 11:1-7. GITR is a single-pass type I transmembrane protein and its extracellular domain (ECD) consists of three cysteine-rich domains, which are typical of the TNFR superfamily.

[3] GITR is multimerized and activated upon interaction with its trimerized ligand GITRL (TNFSF18) resulting in induction of NFκB activation through TRAF2/TRAF5.
15 *See, e.g.,* Pedros, C., Altman, A., and Kong, K. (2018) *Front. Immunol.* 9:2412; and Snell, L.M., et al., (2010) *J. Immunol.*, 185(12):7223-7234. The consequences of GITRL-induced GITR signaling include co-stimulation of T cell proliferation and cytokine release as well as abrogation of Treg suppressive effects. It has also been shown that GITR can be agonized through antibody binding and that this GITR activation may be further enhanced
20 by agonist antibody or GITRL-Fc binding to FcγR; this enhancement is thought to be mediated by increased avidity or receptor multimerization. Therefore, a GITR antagonist is likely to exhibit agonist activity if it is bound on a surface, perhaps through binding FcγRs on a cell surface, resulting in multimerization of GITR and subsequent activation. Thus, a monovalent anti-GITR antibody fragment that efficiently blocks GITRL binding to its
25 receptor and prevents receptor activation without the ability to substantially engage FcγRs is desired. The most straightforward way to ensure there is no possibility of FcγR engagement is to generate antibody fragments that are entirely devoid of the Fc domain. However, antibody fragments that are entirely devoid of the Fc domain, such as Fabs, are known to have a short half-life ($t_{1/2}$), which presents challenges when using it as a
30 therapeutic agent.

[4] Several strategies exist for extending the $t_{1/2}$ of biotherapeutics, which can improve their pharmacokinetic (PK) and/or pharmacodynamic (PD) profiles. Such strategies typically use bulking moieties or neonatal Fc receptor (FcRn)-mediated recycling. In this manner, antibodies (Abs) or fragments thereof (*e.g.*, Fab, Fc, *etc.*);
5 polymers such as polyethylene glycol (PEG), polysialic acid (PSA), hyaluronic acid (HA) and hydroxy-ethyl-starch (HES); fatty acids and other lipids; N- or O-glycosylation; and serum albumin or other plasma proteins (such as transferrin), can be covalently and/or non-covalently bound to a given biotherapeutic to extend its half-life.

[5] International Patent Application published under the Patent Cooperation Treaty
10 (PCT) as WO 2017/096189 (Agenus) discloses, *inter alia*, anti-human GITR antagonist antibodies (including, but not limited to, bispecific antibodies, *e.g.*, antibodies that comprise a first antigen-binding domain that binds to human GITR, and a second antigen-binding domain that doesn't specifically bind to an antigen expressed by a human immune cell), as well as methods of using them. In some embodiments, and in certain *in vitro*
15 assays, certain anti-human GITR antibodies disclosed in WO 2017/096189 behave as antagonists. However, later reports published by the applicant Agenus describe INCAGN1876, also known as ragifilimab, as being an agonist antibody for GITR. *See, e.g.*, Gonzalez, Ana M., et al., AACR Annual Meeting 2017; April 1-5, 2017; Washington, DC, Abstract 3643.

[6] Thus, there still exists a need for anti-human GITR antibodies that 1) bind human
20 GITR with desirable association and dissociation rates for optimal antagonistic activity, 2) block GITRL binding to GITR and prevent GITR activation, 3) lack detectable stimulation of human GITR, 4) have sufficient pharmacokinetic (PK) and/or pharmacodynamic (PD) profiles and demonstrable *in vivo* efficacy as a monotherapy for the treatment and/or
25 prevention of autoimmune disorders, allergic disease, asthma, atopic dermatitis (AtD), joint inflammation, arthritis, rheumatoid arthritis (RA), or other inflammatory disorders such as, inflammatory bowel disease (IBD), Crohn's disease (CD) and/or ulcerative colitis (UC),
5) cause no significant induction of cytokine release, 6) have low immunogenicity (*i.e.*, sufficiently non-immunogenic in cynomolgus monkeys and/or humans), and 7)
30 demonstrate *in vitro* and *in vivo* physical and chemical stability including, but not limited to, thermal stability, solubility, low self-association, and pharmacokinetic characteristics which are acceptable for development and/or use in the treatment of autoimmune disorders,

allergic disease, asthma, AtD, joint inflammation, arthritis, RA, or other inflammatory disorders such as, IBD, CD and/or UC.

[7] Accordingly, the present invention provides novel human GITR antagonist compounds that 1) bind human GITR with desirable association and dissociation rates for optimal antagonistic activity, 2) block GITRL binding to GITR and prevent GITR activation, 3) lack detectable stimulation of human GITR 4) have sufficient pharmacokinetic (PK) and/or pharmacodynamic (PD) profiles and demonstrable *in vivo* efficacy as an monotherapy for the treatment and/or prevention of autoimmune disorders, allergic disease, asthma, atopic dermatitis, joint inflammation, arthritis, rheumatoid arthritis, or other inflammatory disorders such as, IBD, CD and/or UC, 5) cause no significant induction of cytokine release, 6) have low immunogenicity (i.e., sufficiently non-immunogenic in cynomolgus monkeys and/or humans), and 7) demonstrate *in vitro* and *in vivo* physical and chemical stability including, but not limited to, thermal stability, solubility, low self-association, and pharmacokinetic characteristics which are acceptable for development and/or use in the treatment of autoimmune disorders, allergic disease, asthma, AtD, joint inflammation, arthritis, RA, or other inflammatory disorders such as, IBD, CD and/or UC.

[8] The present disclosure provides compounds comprising an anti-human GITR antigen binding fragment comprising: 1) a heavy chain variable region (HCVR) comprising an HCDR1 having the amino acid sequence of SEQ ID NO: 1, an HCDR2 having the amino acid sequence of SEQ ID NO: 2 or 7, an HCDR3 having the amino acid sequence of SEQ ID NO: 3; and 2) a light chain variable region (LCVR) comprising an LCDR1 having the amino acid sequence of SEQ ID NO: 4, an LCDR2 having the amino acid sequence of SEQ ID NO: 5, and an LCDR3 having the amino acid sequence of SEQ ID NO: 6.

[9] In some instances, the compounds herein are of the formula (from amino-terminus (N-terminus) to carboxy-terminus (C-terminus)): X-L-M (wherein the N-terminus of L is fused to the C-terminus of the HC of X and the C-terminus of L is fused to the N-terminus of M); or X-L-M (wherein the N-terminus of L is fused to the C-terminus of the LC of X and the C-terminus of L is fused to the N-terminus of M); or M-L-X (wherein the N-terminus of L is fused to the C-terminus of M and the C-terminus of L is fused to the N-terminus of the HC of X); or M-L-X (wherein the N-terminus of L is fused to the C-

terminus of M and the C-terminus of L is fused to the N-terminus of the LC of X); wherein M is a compound acting as a t¹/₂-extending moiety, L (if present) is a linker, and X is an antibody Fab fragment that binds human GITR. In some instances, M is an albumin-binding VHH, and L can have an amino acid sequence comprising (GGGGQ)_n where n can be from 1 to 15, especially from about 4 to about 8. In other instances, M comprises an amino acid sequence as shown in SEQ ID NO: 13, and L can have an amino acid sequence selected from SEQ ID NOS:11 or 12. In still other instances, L can have one or more additions, deletions, insertions or substitutions such that L has an amino acid sequence having at least about 90% to about 99% sequence similarity to any one of SEQ ID NOS:11 or 12.

[10] The disclosure also describes pharmaceutical compositions that include at least one compound herein and a pharmaceutically acceptable carrier.

[11] Additionally, the disclosure describes methods of using the compounds and pharmaceutical compositions for medicaments.

[12] Furthermore, the disclosure describes uses of the compounds herein in the manufacture of medicaments.

DETAILED DESCRIPTION

[13] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of skill in the art to which the disclosure pertains. Although any methods and materials similar to or equivalent to those described herein can be used in the practice or testing of the analogs, pharmaceutical compositions and methods, the preferred methods and materials are described herein.

[14] Moreover, reference to an element by the indefinite article “a” or “an” does not exclude the possibility that more than one element is present, unless the context clearly requires that there be one and only one element. The indefinite article “a” or “an” thus usually means “at least one.”

[15] *Definitions*

[16] As used herein, “about” means within a statistically meaningful range of a value or values such as, for example, a stated concentration, length, molecular weight, pH, sequence similarity, time frame, temperature, volume, *etc.* Such a value or range can be

within an order of magnitude typically within 20%, more typically within 10%, and even more typically within 5% of a given value or range. The allowable variation encompassed by “about” will depend upon the particular system under study, and can be readily appreciated by one of skill in the art.

5 [17] As used herein, and in reference to one or more of receptors, “activity,” “activate,” “activating” and the like means a capacity of a compound, such as a fusion herein, to bind to and induce a response at the receptor(s), as measured using assays known in the art, such as the *in vitro* assays described below.

10 [18] As used herein, “amino acid” means a molecule that, from a chemical standpoint, is characterized by a presence of one or more amine groups and one or more carboxylic acid groups and may contain other functional groups. As is known in the art, there is a set of twenty amino acids that are designated as standard amino acids and that can be used as building blocks for most of the peptides/proteins produced by any living being. The amino acid sequences in the disclosure contain the standard single letter or three letter codes for
15 the twenty naturally occurring amino acids.

[19] As used herein, “analog” means a compound, such as a synthetic peptide or polypeptide, that activates a target receptor and that elicits at least one *in vivo* or *in vitro* effect elicited by a native agonist for that receptor.

20 [20] The term “antibody,” as used herein, refers to an immunoglobulin molecule that binds an antigen. Embodiments of an antibody include a monoclonal antibody, polyclonal antibody, human antibody, humanized antibody, chimeric antibody, or conjugated antibody. The antibodies can be of any class (e.g., IgG, IgE, IgM, IgD, IgA) and any subclass (e.g., IgG1, IgG2, IgG3, IgG4). An exemplary antibody is an immunoglobulin G (IgG) type antibody comprised of four polypeptide chains: two heavy chains (HC) and two
25 light chains (LC) that are cross-linked via inter-chain disulfide bonds. The amino-terminal portion of each of the four polypeptide chains includes a variable region of about 100-125 or more amino acids primarily responsible for antigen recognition. The carboxyl-terminal portion of each of the four polypeptide chains contains a constant region primarily responsible for effector function. Each heavy chain is comprised of a heavy chain variable
30 region (VH) and a heavy chain constant region. Each light chain is comprised of a light chain variable region (VL) and a light chain constant region. The IgG isotype may be further divided into subclasses (e.g., IgG1, IgG2, IgG3, and IgG4).

[21] The VH and VL regions can be further subdivided into regions of hyper-variability, termed complementarity determining regions (CDRs), interspersed with regions that are more conserved, termed framework regions (FR). The CDRs are exposed on the surface of the protein and are important regions of the antibody for antigen binding specificity. Each VH and VL is composed of three CDRs and four FRs, arranged from amino-terminus to carboxyl-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. Herein, the three CDRs of the heavy chain are referred to as “HCDR1, HCDR2, and HCDR3” and the three CDRs of the light chain are referred to as “LCDR1, LCDR2 and LCDR3”. The CDRs contain most of the residues that form specific interactions with the antigen. Assignment of amino acid residues to the CDRs may be done according to the well-known schemes, including those described in Kabat (Kabat et al., “Sequences of Proteins of Immunological Interest,” National Institutes of Health, Bethesda, Md. (1991)), Chothia (Chothia et al., “Canonical structures for the hypervariable regions of immunoglobulins”, *Journal of Molecular Biology*, 196, 901-917 (1987); Al-Lazikani et al., “Standard conformations for the canonical structures of immunoglobulins”, *Journal of Molecular Biology*, 273, 927-948 (1997)), North (North *et al.*, “A New Clustering of Antibody CDR Loop Conformations”, *Journal of Molecular Biology*, 406, 228-256 (2011)), or IMGT (the international ImMunoGeneTics database available on at www.imgt.org; see Lefranc et al., *Nucleic Acids Res.* 1999; 27:209-212). The North CDR definitions are used for the anti-human GITR antibodies described herein.

[22] The term “antigen-binding fragment” refers to a portion of an antibody that retains the ability to specifically interact with an epitope of an antigen. Examples of antigen binding fragments include, but are not limited to, Fab or Fab’. A “Fab” fragment consists of an entire antibody light chain comprising the light chain variable region (VL) and the light chain constant region (CL), along with the heavy chain variable region (VH) and the heavy chain first constant domain (CH1). Each Fab fragment is monovalent with respect to antigen binding, i.e., it has a single antigen-binding site. A Fab’ fragment differs from the Fab fragment by having a few additional residues at the carboxyl terminus of the CH1 domain including one or more residues from the antibody hinge region. A Fab or Fab’ described herein can be a human Fab or Fab’ or a chimeric Fab or Fab’ that comprises a human CL and CH1.

[23] The terms “bind” and “binds” as used herein are intended to mean, unless indicated otherwise, the ability of a protein or molecule to form a chemical bond or attractive interaction with another protein or molecule, which results in proximity of the two proteins or molecules as determined by common methods known in the art.

5 [24] As used herein, “biotherapeutic” and the like means an amino acid- or nucleic acid-based compounds such as antibodies, coagulation factors, clotting factors, cytokines, enzymes, growth factors, hormones, and fragments thereof, having at least one therapeutic activity/applicability, as well as therapeutic DNA and/or RNA molecules.

[25] As used herein, “conservative substitution” means a variant of a reference peptide
10 or polypeptide that is identical to the reference molecule, except for having one or more conservative amino acid substitutions in its amino acid sequence. In general, a conservatively modified variant includes an amino acid sequence that is at least about 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% identical to a reference amino acid sequence. More specifically, a conservative substitution refers to
15 substitution of an amino acid with an amino acid having similar characteristics (*e.g.*, charge, side-chain size, hydrophobicity/hydrophilicity, backbone conformation and rigidity, *etc.*) and having minimal impact on the biological activity of the resulting substituted peptide or polypeptide. Conservative substitutions of functionally similar amino acids are well known in the art and thus need not be exhaustively described herein.

20 [26] As used herein, “effective amount” means an amount or dose of one or more of the compounds herein, or a pharmaceutically acceptable salt thereof that, upon single or multiple dose administration to an individual in need thereof, provides a desired effect in such an individual under diagnosis or treatment (*i.e.*, may produce a clinically measurable difference in a condition of the individual, for example, reduction in one or more clinical
25 disease activity measures such as American College of Rheumatology (ACR) 20, ACR50, ACR70; Disease Activity Score (DAS); Psoriasis Area and Severity Index (PASI) 50, PASI75, PASI90, PASI100; Systemic Lupus erythematosus disease activity index (SLEDAI); Mayo Score Disease activity index (DAI); Crohn’s disease activity index (CDAI); Geboes score (GS); Robarts Histopathology index (RHI); Atopic dermatitis
30 Severity Index (ADSI); and EULAR Sjogren’s syndrome disease activity index (ESSDAI)). An effective amount can be readily determined by one of skill in the art by using known techniques and by observing results obtained under analogous circumstances.

In determining the effective amount for an individual, a number of factors are considered, including, but not limited to, the species of mammal, its size, age and general health, the specific disease or disorder involved, the degree of or involvement or the severity of the disease or disorder, the response of the individual, the particular compound administered, the mode of administration, the bioavailability characteristics of the preparation administered, the dose regimen selected, the use of concomitant medication, and other relevant circumstances.

[27] As used herein, “extended duration of action” means that binding affinity and activity for a fusion including at least one compound herein and a biotherapeutic herein continues for a period of time greater than a native biotherapeutic, allowing for dosing at least as infrequently as once daily or even thrice-weekly, twice-weekly or once-weekly. The time action profile may be measured using known pharmacokinetic test methods such as those utilized in the Examples below.

[28] The term “Fc region” as used herein refers to a region of an antibody, which comprises the CH2 and CH3 domains of the antibody heavy chain. Optionally, the Fc region may include a portion of the hinge region or the entire hinge region of the antibody heavy chain.

[29] As used herein, “glucocorticoid-induced TNFR-related protein” or “GITR”, also known as tumor necrosis factor receptor superfamily member 18 (TNFRSF18), means a GITR protein obtained or derived from any species, such as a mammalian species, especially a human. GITR includes both native GITR (*i.e.*, full-length) and variations thereof (*i.e.*, additions, deletions, insertions and/or substitutions of native GITR). One sequence for human GITR full-length (but without the signal peptide) is set forth in SEQ ID NO:20 (*see also*, UniProt/SwissProt Database Accession No. Q9Y5U5). One sequence for human GITR ECD (but without the signal peptide) is set forth in SEQ ID NO:21.

[30] As used herein, “half-life” or “ $t_{1/2}$ ” means the time it takes for one-half of a quantity of a compound, such as a fusion protein described herein, to be removed from a fluid or other physiological space such as serum or plasma of an individual by biological processes. Alternatively, $t_{1/2}$ also can mean a time it takes for a quantity of such a fusion protein to lose one-half of its pharmacological, physiological or radiological activity.

[31] As used herein, “half-maximal effective concentration” or “EC₅₀” means a concentration of compound that results in 50% activation/stimulation of an assay endpoint, such as a dose-response curve.

[32] As used herein, “in combination with” means administering at least one of the fusion proteins herein either simultaneously, sequentially or in a single combined formulation with one or more additional therapeutic agents.

[33] As used herein, “individual in need thereof” means a mammal, such as a human, with a condition, disease, disorder or symptom requiring treatment or therapy, including for example, those listed herein. In particular, the preferred individual to be treated is a human.

[34] As used herein, “long-acting” means that binding affinity and activity of a composition herein continues for a period of time greater than native peptide or protein, allowing for dosing at least as infrequently as once daily or even thrice-weekly, twice-weekly, once-weekly or monthly. The time action profile of the compounds herein may be measured using known pharmacokinetic test methods such as those described in the Examples below.

[35] The terms “nucleic acid” or “polynucleotide”, as used interchangeably herein, refer to polymers of nucleotides, including single-stranded and / or double-stranded nucleotide-containing molecules, such as DNA, cDNA and RNA molecules, incorporating native, modified, and / or analogs of, nucleotides. Polynucleotides of the present disclosure may also include substrates incorporated therein, for example, by DNA or RNA polymerase or a synthetic reaction.

[36] As used herein, “non-standard amino acid” means an amino acid that may occur naturally in cells but does not participate in peptide synthesis. Non-standard amino acids can be constituents of a peptide and oftentimes are generated by modification of standard amino acids in the peptide (*i.e.*, via post-translational modification). Non-standard amino acids can include D-amino acids, which have an opposite absolute chirality of the standard amino acids above.

[37] As used herein, “oligomer” means a molecule having a few similar or identical repeating units that could be derived from copies of a smaller molecule, its monomer. These monomers can be joined by bonds that are either strong or weak, covalent or non-covalent (*e.g.*, intramolecular).

[38] As used herein, “patient,” “subject” and “individual,” are used interchangeably herein, and mean a mammal, especially a human. In certain instances, the individual is further characterized with a condition, disease, disorder or symptom that would benefit from administering a compound or composition herein.

5 [39] As used herein, “pharmaceutically acceptable buffer” means any of the standard pharmaceutical buffers known to one of skill in the art.

[40] As used herein, “sequence similarity” means a quantitative property of two or more nucleic acid sequences or amino acid sequences of biological compounds such as, for example, a correspondence over an entire length or a comparison window of the two or
10 more sequences. Sequence similarity can be measured by (1) percent identity or (2) percent similarity. Percent identity measures a percentage of residues identical between two biological compounds divided by the length of the shortest sequence, whereas percent similarity measures identities and, in addition, includes sequence gaps and residue similarity in the evaluation. Methods of and algorithms for determining sequence similarity
15 are well known in the art and thus need not be exhaustively described herein. A specified percentage of identical nucleotide or amino acid positions is at least about 75%, 80%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or higher.

[41] As used herein, “treating” or “to treat” means managing and caring for an individual having a condition, disease, disorder or symptom for which administration of a
20 compound herein is indicated for the purpose of attenuating, restraining, reversing, slowing or stopping progression or severity of the condition, disease, disorder or symptom. Treating includes administering a compound herein or composition containing a compound herein to the individual to prevent the onset of symptoms or complications, alleviating the symptoms or complications, or eliminating the condition, disease, disorder or symptom.
25 Treating includes administering a compound herein or composition containing a compound herein to the individual to result in such as, for example, decreased (or prevented) autoimmunity and/or reduced (or prevented) allergic disease, asthma, atopic dermatitis, joint inflammation, arthritis, rheumatoid arthritis, or other inflammatory disorders such as, IBD, CD and/or UC. The individual to be treated is a mammal, especially a human.

30 [42] The term “therapeutically effective amount,” as used herein, refers to an amount of a protein or nucleic acid or vector or composition that will elicit the biological or medical response of a subject, for example, reduction or inhibition of an enzyme or a protein

activity, or ameliorate symptoms, alleviate conditions, slow or delay disease progression, or prevent a disease, etc. In a non-limiting embodiment, the term “a therapeutically effective amount” refers to the amount of a protein or nucleic acid or vector or composition that, when administered to a subject, is effective to at least partially alleviate, inhibit, prevent and/or ameliorate a condition, or a disorder or a disease.

[43] As used herein, “variable heavy homodimer,” “VHH” or “VHH moiety” means a form of single-domain antibody, especially an antibody fragment of a single, monomeric variable region of a heavy chain only antibody (HcAb), which has a very small size of about 15 kDa. It has been found herein that engineered/modified VHH-based compounds can be used as a pharmacokinetic enhancer to extend the duration of action of and/or to improve the $t_{1/2}$ of biotherapeutics. The VHH-based compounds bind serum albumin; however, the VHH-based compounds can be used to bind IgG (including Fc domain), neonatal Fc receptor (FcRn) or other long-lasting serum proteins. The VHH-based compound therefore can be used to improve the $t_{1/2}$ of a compound such as a peptide or protein or even other molecules such as, for example, small molecules.

[44] Certain abbreviations are defined as follows: “ACR” refers to urine albumin/urine creatinine ratio; “AUC” refers to area under the curve; “AUC_{0-inf}” refers to area under the curve from time 0 hours to infinity; “cAMP” refers to cyclic adenosine monophosphate; “C₀” refers to estimated plasma concentration at time zero; “CL” refers to clearance following IV administration; “CL/F” refers to apparent clearance following SQ administration; “C_{max}” refers to maximum observed plasma concentration “CMV” refers to cytomegalovirus; “DNA” refers to deoxyribonucleic acid; “ECD” refers to extracellular domain; “EDC” refers to 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride; “ETA” refers to ethanolamine; “GS” refers to glutamine synthetase; “HC” refers to heavy chain; “HIC” refers to hydrophobic interaction chromatography; “hr” refers to hour or hours; “IV” refers to intravenous; “kDa” refers to kilodaltons; “LC” refers to light chain; “LC-MS” refers to liquid chromatography-mass spectrometry; “min” refers to minute or minutes; “MS” refers to mass spectrometry; “MSX” refers to methionine sulfoximine; “NHS” refers to N-hydroxysuccinimide; “OtBu” refers to O-tert-butyl; “PEI” refers to polyethylenimine; “RP-HPLC” refers to reversed-phase high performance liquid chromatography; “sec” refers to second or seconds; “NaOAc” refers to sodium acetate; “rcf” means relative centrifugal force; “RT” means room temperature; “RU” means

resonance units; “SQ” refers to subcutaneous; “SEC” refers to size-exclusion chromatography; “SEM” refers to standard error of the mean; “SPR” means surface plasmon resonance; “ $t_{1/2}$ ” refers to half-life; “TFA” refers to trifluoroacetic acid; “ T_{max} ” refers to time of maximum observed concentration; and “Trt” refers to trityl.

5 [45] *Anti-human GITR Antigen Binding Fragment Compounds*

[46] The present disclosure provides an anti-human GITR antigen binding fragment compound comprising: 1) a heavy chain variable region (HCVR) comprising an HCDR1 having the amino acid sequence of SEQ ID NO: 1, an HCDR2 having the amino acid sequence of SEQ ID NO: 2 or 7, an HCDR3 having the amino acid sequence of SEQ ID
10 NO: 3; and 2) a light chain variable region (LCVR) comprising an LCDR1 having the amino acid sequence of SEQ ID NO: 4, an LCDR2 having the amino acid sequence of SEQ ID NO: 5, and an LCDR3 having the amino acid sequence of SEQ ID NO: 6. In some instances, the anti-human GITR antigen binding fragment compound comprises a Fab comprising a human kappa CL and a human IgG1 CH1.

15 [47] *Compounds Having VHH-Based Half-Life Extenders*

[48] Briefly, certain compounds herein are of the formula (from N-terminus to C-terminus): X-L-M, wherein M is a compound acting as a $t_{1/2}$ -extending moiety, L (if present) is a linker, and X is an antibody Fab fragment that binds human GITR. In some instances, L can have an amino acid sequence comprising (GGGGQ)_n, (GGGQ)_n,
20 (GGGGS)_n, (PGPQ)_n, (PGPA)_n, GGGG(AP)_nGGGG, (GGE)_n, (GGGGE)_n, (GGK)_n, (GGGGK)_n, GGGG(EP)_nGGGG, GGGG(KP)_nGGGG, (PGPE)_n or (PGPK)_n, where n can be from 1 to 15, especially from about 5 to about 10. In some instances, M is an albumin-binding VHH, and L is a peptide comprising an amino acid sequence of (GGGGQ)_n where n can be from 1 to 15, especially from about 4 to about 8. In other instances, M comprises
25 an amino acid sequence as shown in SEQ ID NO: 13, and L can have an amino acid sequence selected from SEQ ID NOS:11 or 12. In still other instances, L can have one or more additions, deletions, insertions or substitutions such that L has an amino acid sequence having at least about 90% to about 99% sequence similarity to any one of SEQ ID NOS:11 or 12. In still other instances, L can be a polymer such as a polyethylene glycol (PEG),
30 especially (PEG)_n, where n can be from 1 to 20.

[49] In some instances, the compounds disclosed herein are of the formula (from N-terminus to C-terminus): X-L-M, wherein M comprises an amino acid sequence as shown in SEQ ID NO:13 or having an amino acid sequence having at least about 90% to about 99% sequence similarity thereto, where L (if present) is a linker, and wherein X is a Fab that binds human GITR. In some instances, L can have an amino acid sequence comprising (GGGGQ)_n where n can be from 1 to 15, especially from about 4 to about 8. In other instances, L can have an amino acid sequence selected from SEQ ID NOS:11 or 12. In still other instances, L can have one or more additions, deletions, insertions or substitutions such that L has an amino acid sequence having at least about 90% to about 99% sequence similarity to any one of SEQ ID NOS:11 or 12. In still other instances, L can be a polymer such as a polyethylene glycol (PEG), especially (PEG)_n, where n can be from 1 to 20. Preferably, the compound is a human GITR antagonist.

[50] *Pharmaceutical Compositions and Kits*

[51] In some instances, the anti-human GITR antigen binding fragment compounds disclosed herein such as the anti-human GITR Fabs, the anti-human GITR Fab fusions or conjugates to albumin-binding VHHs thereof (such as Antibody I and Antibody II disclosed herein) can be formulated as pharmaceutical compositions, which can be administered by parenteral routes (*e.g.*, intravenous, intraperitoneal, intramuscular, subcutaneous or transdermal). Such pharmaceutical compositions and techniques for preparing the same are well known in the art. *See, e.g.*, Remington, "The Science and Practice of Pharmacy" (D.B. Troy ed., 21st Ed., Lippincott, Williams & Wilkins, 2006). In particular instances, the compositions are administered SQ or IV. Alternatively, however, the compositions can be formulated in forms for other pharmaceutically acceptable routes such as, for example, tablets or other solids for oral administration; time release capsules, and any other form currently used, including creams, lotions, inhalants and the like.

[52] As noted above, and to improve their *in vivo* compatibility and effectiveness, the VHH-based fusions or VHH-based conjugates herein may be reacted with any number of inorganic and organic acids/bases to form pharmaceutically acceptable acid/base addition salts. Pharmaceutically acceptable salts and common techniques for preparing them are well known in the art (*See, e.g.*, Stahl *et al.*, "Handbook of Pharmaceutical Salts: Properties, Selection and Use" (2nd Revised Ed. Wiley-VCH, 2011)). Pharmaceutically

acceptable salts for use herein include sodium, trifluoroacetate, hydrochloride and acetate salts.

[53] The compounds herein may be administered by a physician or self-administered using an injection. It is understood the gauge size and amount of injection volume can be readily determined by one of skill in the art. However, the amount of injection volume can be $\leq$ about 2 mL or even $\leq$ about 1 mL, and the needle gauge can be $\geq$ about 27 G or even $\geq$ about 29 G.

[54] The disclosure also provides and therefore encompasses novel intermediates and methods useful for synthesizing the compounds herein, or a pharmaceutically acceptable salt thereof. The intermediates and compounds can be prepared by a variety of techniques that are well known in the art. For example, a method using recombinant synthesis is illustrated in the Examples below. The specific steps for each of the techniques described may be combined in different ways to prepare the compounds. The reagents and starting materials are readily available to one of skill in the art.

[55] The compounds herein are generally effective over a wide dosage range. Exemplary doses of the compounds or of pharmaceutical compositions including the same can be milligram (mg) or microgram (μ g) amounts per kilogram (kg) of an individual. In this manner, a daily dose can be from about 1 μ g to about 1000 mg.

[56] Here, the effective amount of the compound in a pharmaceutical composition can be a dose of about 2.5 mg to about 1000 mg. One of skill in the art, however, understands that in some instances the effective amount (*i.e.*, dose/dosage) may be below the lower limit of the aforesaid range and be more than adequate, while in other cases the effective amount may be a larger dose and may be employed with acceptable side effects.

[57] In addition to a compound herein, the pharmaceutical composition also can include at least one additional therapeutic agent such as, for example, a therapeutic agent typically used as the standard of care in of a particular condition, disease and disorder (*e.g.*, a cardiovascular, neurological, immunological, metabolic, oncological, psychological, pulmonological and/or renal condition, disease or disorder).

[58] In this manner, a pharmaceutical composition can include an effective amount of one or more compounds herein, a pharmaceutically acceptable carrier and optionally at least one additional therapeutic agent.

[59] Alternatively, the compounds herein can be provided as part of a kit. In some instances, the kit includes a device for administering at least one compound (and optionally at least one additional therapeutic agent) to an individual. In certain instances, the kit includes a syringe and needle for administering the at least one compound (and optionally at least one additional therapeutic agent). In particular instances, the compound (and optionally at least one additional therapeutic agent) is pre-formulated in aqueous solution within the syringe.

[60] *Methods of Making and Using VHH-Based Compounds Acting as Half-Life Extenders or Fusions and Conjugates Thereof*

[61] The compounds herein can be made via any number of standard recombinant DNA methods or standard chemical peptide synthesis methods known in the art. With regard to recombinant DNA methods, one can use standard recombinant techniques to construct a polynucleotide having a nucleic acid sequence that encodes an amino acid sequence for a compound (*i.e.*, fusion peptide or fusion protein or fusion conjugate), incorporate that polynucleotide into recombinant expression vectors, and introduce the vectors into host cells, such as bacteria, yeast and mammalian cells, to produce the compound. (*See, e.g.*, Green & Sambrook, "Molecular Cloning: A Laboratory Manual" (Cold Spring Harbor Laboratory Press, 4th ed. 2012)).

[62] With regard to recombinant DNA methods, the compounds herein can be prepared by producing a protein or precursor protein molecule using recombinant DNA techniques. DNA, including cDNA and synthetic DNA, may be double-stranded or single-stranded, and the coding sequences therein encoding a compound herein may vary as a result of the redundancy or degeneracy of the genetic code. Briefly, the DNA sequences encoding the compounds herein are introduced into a host cell to produce the compound or precursor thereof. The host cells can be bacterial cells such as K12 or B strains of *Escherichia coli*, fungal cells such as yeast cells, or mammalian cells such as Chinese hamster ovary (CHO) cells.

[63] An appropriate host cell is transiently or stably transfected or transformed with an expression system, such as expression vectors, for producing a compound herein or a precursor thereof. Expression vectors typically are replicable in the host organisms either as episomes or as an integral part of the host chromosomal DNA. Commonly, expression vectors will contain selection markers such as, for example, tetracycline, neomycin, G418

and dihydrofolate reductase, to permit selection of those cells transformed with the desired DNA sequences.

[64] The specific biosynthetic or synthetic steps for each of the steps described herein may be used, not used or combined in different ways to prepare the compounds herein.

5 [65] With regard to chemical peptide synthesis methods, one can use standard manual or automated solid-phase synthesis procedures. For example, automated peptide synthesizers are commercially available from, for example, Applied Biosystems (Foster City, CA) and Protein Technologies Inc. (Tucson, AZ). Reagents for solid-phase synthesis are readily available from commercial sources. Solid-phase synthesizers can be used
10 according to the manufacturer's instructions for blocking interfering groups, protecting amino acids during reaction, coupling, deprotecting and capping of unreacted amino acids.

[66] The methods can include the steps described herein, and these may be, but not necessarily, carried out in the sequence as described. Other sequences, however, also are conceivable. Moreover, individual or multiple steps may be carried out either in parallel
15 and/or overlapping in time and/or individually or in multiply repeated steps. Furthermore, the methods may include additional, unspecified steps.

[67] Such methods therefore can include selecting an individual having, for example, a autoimmune condition, disease or disorder, or who is predisposed to the same.

[68] The methods also can include administering to the individual an effective amount
20 of at least one compound herein, which may be in the form of a pharmaceutical composition as also described herein. In some instances, the compound/pharmaceutical composition can include an additional therapeutic agent.

[69] The concentration/dose/dosage of the compound and optional additional therapeutic agent are discussed elsewhere herein.

25 [70] With regard to a route of administration, the compound or pharmaceutical composition including the same can be administered in accord with known methods such as, for example, orally; by injection (*i.e.*, intra-arterially, intravenously, intraperitoneally, intracerebrally, intracerebroventricularly, intramuscularly, intraocularly, intraportally or intralesionally); by sustained release systems, or by implantation devices. In certain
30 instances, the compound or pharmaceutical composition including the same can be administered SQ by bolus injection or continuously.

[71] With regard to a dosing frequency, the compound or pharmaceutical composition including the same can be administered daily, every other day, three times a week, two times a week, one time a week (*i.e.*, weekly), biweekly (*i.e.*, every other week), or monthly. In certain instances, the compound or pharmaceutical composition including the same is administered SQ every other day, SQ three times a week, SQ two times a week, SQ one time a week, SQ every other week or SQ monthly. In particular instances, the compound or pharmaceutical composition including the same is administered SQ one time a week (QW).

[72] Alternatively, and if administered IV, the compound or pharmaceutical composition including the same is administered IV every other day, IV three times a week, IV two times a week, IV one time a week, IV every other week or IV monthly. In particular instances, the compound or pharmaceutical composition including the same is administered IV one time a week (IW).

[73] With regard to those instances in which the compound or pharmaceutical composition including the same is administered in combination with an effective amount of at least one additional therapeutic agent, the additional therapeutic agent can be administered simultaneously, separately or sequentially with the compound or pharmaceutical composition including the same.

[74] Moreover, the additional therapeutic agent can be administered with a frequency same as the compound or pharmaceutical composition including the same (*i.e.*, every other day, twice a week, or even weekly). Alternatively, the additional therapeutic agent can be administered with a frequency distinct from the compound or pharmaceutical composition including the same. In other instances, the additional therapeutic agent can be administered SQ. In other instances, the additional therapeutic agent can be administered IV. In still other instances, the additional therapeutic agent can be administered orally.

[75] It is further contemplated that the methods may be combined with additional therapeutic agents other than those discussed above.

EXAMPLES

[76] The following non-limiting examples are offered for purposes of illustration, not
5 limitation.

[77] POLYPEPTIDE EXPRESSION

[78] Example 1: Recombinant Expression of Antibody I

[79] Antibody I is an anti-human GITR Fab – albumin-binding VHH fusion having a
heavy chain amino acid sequence of:

10 QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHEYADSVKGRFTISRDNKNTLYLQMNSLRAEDTAVYYCARENNWAPDY
WGQGTLLTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSG
ALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVE
PKSCDKTHTGGGGQGGGGQGGGGQGGGGQGGGGQEVQLLES GGGLVQPGGSL
15 RLSCAASGRYIDETAVAWFRQAPGKGREFVAGIGGGVDITYYADSVKGRFTISR
DNKNTLYLQMNSLRPEDTAVYYCAARPGRPLITSKVADLYPYWGQGTLLTVSSP
P (SEQ ID NO:14); and a light chain amino acid sequence of:
DIQMTQSPSSLSASVGDRVTITCRASQDISNSLAWYQQKPGKAPKRLIYAAFSLQS
GVPSRFSGSGSGTEFTLTISSLQPEDFATYYCYQYYNYPSAFGGGTKLEIKRTVAA
20 PSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQD
SKDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID
NO:16).

[80] The antibody with the heavy chain of SEQ ID NO:14 and the light chain of SEQ
ID NO:16 is generated in a mammalian cell expression system using CHOK1 cell
25 derivatives (Lonza Biologics Inc.). The cDNA sequences encoding SEQ ID NO:14 and
SEQ ID NO:16 are sub-cloned into GS-containing expression plasmid backbones
(pEE12.4-based plasmids; Lonza Biologics Inc.). The cDNA sequence is fused in frame
with the coding sequence of a signal peptide sequence, METDTLLLWVLLLWVPGSTG
(SEQ ID NO:22), to enhance secretion of the antibody into the tissue culture medium. The
30 expression is driven by the viral CMV promoter.

[81] For generating the antibody via transient transfection, CHOK1 cells are
transfected with an equal stoichiometric ratio of the recombinant expression plasmids using

a PEI-based method. Briefly, the appropriate volume of CHOK1 suspension cells at a density of 4×10^6 cells/mL is transferred in shake flasks, and both PEI and recombinant plasmid DNA are added to the cells. Cells are incubated in a suspension culture at 32°C for 6 days. At the end of the incubation period, cells are removed by low-speed centrifugation and the antibody is purified from the conditioned medium.

[82] Alternatively, and for generating the antibody via stable transfections, CHOK1 cells are stably transfected using electroporation and the appropriate amount of recombinant expression plasmid, and the transfected cells are maintained in suspension culture at an adequate cell density. Selection of the transfected cells is accomplished by growth in 25 μ M MSX-containing serum-free medium and incubated at about 35°C-37°C and about 5%-7% CO₂. Subsequently, cells are removed by low-speed centrifugation and the antibody is purified from the conditioned medium.

[83] The antibody is secreted into the media from the CHO cells, which is purified by Protein A affinity chromatography followed by cation exchange chromatography. Specifically, the antibody from harvested media is captured onto MabSelect Prisma Protein A resin (Cytiva). The resin then is briefly washed with a wash buffer, such as a phosphate-buffered saline (PBS; pH 7.4) or a buffer containing Tris, to remove non-specifically bound material. The protein is eluted from the resin with a low pH solution, such as 10 mM citric acid pH 3. Fractions containing the antibody are pooled and may be held at a low pH to inactivate potential viruses. The pH may be neutralized by adding a base such as 0.1 M Tris pH 8.0. The antibody may be further purified by ion exchange chromatography using resins such as POROS 50 HS (ThermoFisher). The antibody may be eluted from the column using a 0 to 1M NaCl gradient in 20 mM sodium acetate, pH 5.0 over 20 column volumes.

[84] Purified antibody may be buffer exchanged into phosphate buffered saline or, alternatively, passed through a viral retention filter such as Planova 20N (Asahi Kasei Medical) followed by concentration/diafiltration into phosphate buffered saline using tangential flow ultrafiltration on a regenerated cellulose membrane (Millipore).

[85] The antibody therefore is prepared in this manner or in a similar manner that would be readily determined by one of skill in the art.

[86] Table 1: SEQ ID NOs for Antibody I

Antibody I	
Amino Acid Sequence for:	SEQ ID NO:
HCDR1	1
HCDR2	2
HCDR3	3
LCDR1	4
LCDR2	5
LCDR3	6
HCVR	8
LCVR	10
Linker	11
Albumin-binding VHH	13
HC anti-GITR Fab – VHH Fusion	14
LC	16
DNA Sequence for:	SEQ ID NO:
HC anti-GITR Fab – VHH Fusion	17
LC	19

[87] Example 2: Recombinant Expression of Antibody II

[88] Antibody II is an anti-human GITR Fab – albumin-binding VHH fusion having a heavy chain amino acid sequence of:

5 QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHELYADSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARENNWAPDY
WGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSG
ALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVE
PKSCDKTHTGGGGQGGGGQGGGGQGGGGQGGGGQEVQLLES GGGLVQPGGSL
10 RLSCAASGRYIDETAVAWFRQAPGKGREFVAGIGGGVDITYYADSVKGRFTISR
DN SKNTLYLQMNSLRPEDTAVYYCAARPGRPLITSKVADLYPYWGQGTLVTVSSP
P (SEQ ID NO:15)

and a light chain amino acid sequence of:

DIQMTQSPSSLSASVGDRVTITCRASQDISNSLAWYQQKPGKAPKRLIYAAFSLQS
15 GVPSRFSGSGSGTEFTLTISSLQPEDFATYYCYQYNYNPSAFGQGTKLEIKRTVAA
PSVFI FPPSDEQLKSGTASVVCLLNFPREAKVQWKVDNALQSGNSQESVTEQD
SKDSTYSLSSLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID
NO:16).

[89] The antibody with the heavy chain of SEQ ID NO:15 and the light chain of SEQ
20 ID NO:16 is generated essentially as described for Example 1 except that cDNA sequences
encoding SEQ ID NOs:15 and 16 are used in the expression plasmids.

[90] Table 2: SEQ ID NOs for Antibody II

Antibody II	
Amino Acid Sequence for:	SEQ ID NO:
HCDR1	1
HCDR2	7
HCDR3	3
LCDR1	4
LCDR2	5
LCDR3	6
HCVR	9
LCVR	10
Linker	11
Albumin-binding VHH	13
HC anti-GITR Fab – VHH Fusion	15
LC	16
DNA Sequence for:	SEQ ID NO:
HC anti-GITR Fab – VHH Fusion	18
LC	19

[91] Example 3: Antibody Binding to Albumin Orthologs by SPR

5 [92] *In vitro* binding of the antibodies (i.e., anti-human GITR Fab – albumin-binding VHH fusions) to human, cynomolgus monkey, mouse, rat, pig, dog, cow and rabbit serum albumin is determined by SPR at 25°C. In particular, the affinity of Antibodies I and II to serum albumin of these species is summarized below in Tables 3 and 4, respectively.

10 [93] Binding of Antibody I and Antibody II to various serum albumins is carried out on Biacore 8K instrument. The immobilization of the serum albumin to a Series S Sensor Chip CM5 (Cytiva 29149603) surface is performed according to the manufacturer's instructions (Amine Coupling Kit BR-1000-50). Briefly, carboxyl groups on the sensor chip surfaces (flow cell 1 and 2) are activated by injecting 70 µL of a mixture containing 75 mg/ml 1-Ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC), and

11.5 mg/ml N-Hydroxysuccinimide (NHS) at 10 μ l/min. Human, cynomolgus monkey, rat, mouse, dog, pig, cow, and rabbit serum albumin are diluted in 10 mM sodium acetate pH 4.0 (BR-1003-49) at 0.8, 0.8, 0.8, 2.5, 0.8, 1, 1, and 1.5 μ g/ml then injected over the activated chip surfaces (flow cell 2, channel 1 to 8) at 10 μ l/min for 100 seconds. Human
5 serum albumin was obtained from Sigma Aldrich (St. Louis, MO) (Cat. No. A8763). Cynomolgus monkey serum albumin was obtained from Athens R&T (Athens, GA) (Cat. No. 16-16-011202-CM). Rat serum albumin was obtained from Sigma Aldrich (St. Louis, MO) (Cat. No. A4538). Mouse serum albumin was obtained from Sigma Aldrich (St. Louis, MO) (Cat. No. A3139). Dog serum albumin was obtained from Molecular Innovations
10 (Novi, MI) (Cat. No. DSA-1213 NC0739153). Pig serum albumin was obtained from Sigma Aldrich (St. Louis, MO) (Cat. No. A4414). Cow serum albumin was obtained from Sigma Aldrich (St. Louis, MO) (Cat. No. A7030). Rabbit serum albumin was obtained from Fitzgerald Industries International (Acton, MA) (Cat. No. 30R-3303).

[94] The serum albumins are covalently immobilized through free amines onto a
15 carboxymethyl dextran-coated sensor chip CM5 at surface densities of 29 – 52 resonance units (RU) for human, cynomolgus monkey, rat, mouse, dog, pig, and cow as well as 118 resonance units (RU) for rabbit serum albumin. Excess reactive groups on the surfaces (flow cell 1 and 2) are deactivated by injecting 70 μ l of 1 M Ethanolamine hydrochloride-NaOH pH 8.5.

20 [95] The antibodies of Examples 1 and 2 (i.e., Antibody I and II, respectively) are diluted in HBS-EP+ buffer (10 mM HEPES pH 7.6, 150 mM NaCl, 3 mM EDTA, 0.05% Polysorbate 20) at concentrations of 1000, 333.3, 111.1, 37.04, 12.35, 4.12, 1.37, 0.457, 0.152, 0.051 and 0.017 nM. 180 μ l of sample are individually injected sequentially across the immobilized serum albumins on the chip's surface and dissociated for 600 sec at
25 60 μ l/min flow rate at 25°C. The surface is regenerated by injecting 10 mM glycine-HCl pH 1.5 (BR-1003-54) at 60 μ l/min for 100 sec. The resulting sensorgrams are analyzed using Biacore 8K Insight Evaluation Software (version 3.0.11.15423) 1:1 binding kinetics model fitting to calculate the binding kinetic parameters: association rate (k_a), dissociation rate (k_d), and equilibrium dissociation constant (K_D). K_D is determined as 0.25, 4.4, 53,
30 44, 100, 20, and 460 nM for human, cynomolgus monkey, mouse, rat, pig, dog and cow serum albumin binding, respectively, with Antibody I (Table 3). K_D is determined as 0.4,

5.9, 42, 51, 99, 20 and 430 nM for human, cynomolgus monkey, mouse, rat, pig, dog and cow serum albumin binding, respectively, with Antibody II (Table 4).

- [96] Table 3: Binding Kinetics of Antibody I to Human, Cynomolgus Monkey,
5 Mouse, Rat, Pig, Dog, Cow and Rabbit Serum Albumin at 25°C.

Binding to Immobilized Serum Albumins (SA)	k_a (1/Ms)	k_d (1/s)	K_D (M)
Human SA	2.6E+05	6.5E-05	2.5E-10
Cyno SA	1.9E+05	8.2E-04	4.4E-09
Mouse SA	1.8E+05	9.4E-03	5.3E-08
Rat SA	1.6E+05	7.0E-03	4.4E-08
Pig SA	1.2E+05	1.3E-02	1.0E-07
Dog SA	1.7E+05	3.5E-03	2.0E-08
Cow SA	2.0E+05	9.1E-02	4.6E-07
Rabbit SA	No binding		

- [97] Table 4: Binding Kinetics of Antibody II to Human, Cynomolgus Monkey,
Mouse, Rat, Pig, Dog, Cow and Rabbit Serum Albumin at 25°C.

Binding to Immobilized Serum Albumins (SA)	k_a (1/Ms)	k_d (1/s)	K_D (M)
Human SA	1.9E+05	7.8E-05	4.0E-10
Cyno SA	1.5E+05	8.7E-04	5.9E-09
Mouse SA	2.3E+05	9.6E-03	4.2E-08
Rat SA	1.4E+05	7.3E-03	5.1E-08
Pig SA	1.2E+05	1.2E-02	9.9E-08
Dog SA	1.7E+05	3.4E-03	2.0E-08
Cow SA	2.0E+05	8.7E-02	4.3E-07
Rabbit SA	No binding		

[98] Example 4: Antibody Binding to GITR Expressing Cells

[99] Jurkat human GITR/NFkB-Luc2 cells (CS184004) were purchased from Promega and maintained in RPMI1640 media + 10% FBS (HyClone SH30070.3) + 400 µg/mL hygromycin B + 600 µg/mL G418.

[100] The NFkB reporter pNiFty2-Luc (InvivoGen) is introduced into Jurkat cells (ATCC) by electroporation and transfectants are selected with 400 µg/mL zeocin for 2 weeks. The resulting Jurkat NFkB-Luc cell line is transduced with cynomolgus monkey GITR lentivirus and selected with 0.5 µg/mL puromycin for 1 week. Jurkat cyno
10 GITR/NFkB-Luc cells are maintained in RPMI1640 media + 10% FBS (HyClone SH30070.3) + 400 µg/mL zeocin + 0.5 µg/mL puromycin.

[101] Jurkat human GITR/NFkB-Luc2 and Jurkat cynomolgus monkey GITR/NFkB-Luc cells are resuspended in FACS buffer (PBS + 1% BSA + 0.01% sodium azide) at 1 million cells/mL and 5 µl Fc block/mL (BioLegend) is added and incubated at 4°C for 20 min.
15 Cells are washed with FACS buffer and resuspended at 1e6 cells/mL in FACS buffer and added to a polypropylene 96-well plate at 100 µl/well for 100,000 cells/well. 100 µl/well of 2X antibody dose titrations diluted in FACS buffer are added to cells and incubated 45 minutes at 4°C. Cells are washed twice with 200 µl/well FACS buffer and resuspended in 12.5 µg/mL anti-human Ig light chain kappa/PE secondary antibody (Invitrogen #PA1-
20 74408) in FACS buffer and incubated for 45 minutes at 4°C. Cells are washed twice with 200 µl/well FACS buffer and resuspended in 200 µl FACS buffer. Samples are read on a Millipore EasyCyte Cytometer and median fluorescence intensity values are calculated using GuavaSoft 3.3 InCyte software. EC₅₀ values are calculated for each of 3 experiment replicates and the EC₅₀ Geometric Mean +/-Error (Delta Method) is calculated from these
25 3 results. The cell binding results shown in Table 5 indicate that both Antibody I and Antibody II bind potently to human GITR and cynomolgus monkey GITR ("cyno GITR"). On the other hand, an adalimumab Fab-albVHH used as a negative control for this study demonstrated negligible binding to human GITR and cynomolgus monkey GITR (data not shown).

[102] Table 5: *In Vitro* Potency of Antibodies Binding to Jurkat GTR cell lines.

Compound	Human GTR cell binding EC ₅₀ nM GeoMean	Error (delta method)	N	Cyno GTR cell binding EC ₅₀ nM GeoMean	Error (delta method)	N
Antibody I	6.80	0.30	3	3.06	0.04	3
Antibody II	3.25	0.12	3	2.34	0.06	3

[103] Example 5: Antibody *In Vitro* GITRL Antagonism at Human and Cyno GTR

- 5 [104] Jurkat human GTR/NFkB-Luc2 or Jurkat cyno GTR/NFkB-Luc2 cells are starved overnight in assay media (RPMI1640 + 1% FBS) at 37°C, 5% CO₂ and resuspended the next day in assay media (RPMI1640 + 1% FBS) at 2e6 cells/mL. 25 µL/well of cell suspension is added to white opaque 96-well plates (Corning Costar) for 5e5 cells/well. 50 µL/well of 2X antibody dose titrations diluted in assay media are added, immediately
- 10 followed by addition of 25 µL/well of 4X (12 nM) human GITRL or cyno GITRL, respectively, diluted in assay media. Plates are incubated at 37°C, 5% CO₂ for 6 hours and then placed at room temperature for 15 minutes. 100 µL/well of BioGlo luciferase reagent (Promega) is added per well and incubated with shaking for 5 minutes at room temperature. Luminescence is measured with a BioTek SynergyNeo2 plate reader with
- 15 Gen5 software. IC₅₀ values are calculated for GITRL inhibition by GTR antagonist antibody treatments from each of 3 experiment replicates and the IC₅₀ Geometric Mean with Error (delta method) is calculated from these 3 results.

[105] Table 6: *In Vitro* Potency of GTR Antagonist Antibodies for Inhibition of
20 GITRL Stimulation of Jurkat GTR/NFkB luciferase Cells.

Compound	Human GTR IC ₅₀ nM GeoMean	Error (delta method)	N	Cyno GTR IC ₅₀ nM GeoMean	Error (delta method)	N
Antibody I	4.10	0.98	3	2.27	0.37	3
Antibody II	1.68	0.18	3	1.26	0.09	3

[106] The luciferase reporter functional bioassay results in Table 6 demonstrate that both Antibody I and Antibody II potently inhibit human GITRL stimulation of human GTR and cyno GITRL stimulation of cyno GTR.

5 [107] Example 6: Antibody *In Vitro* Agonism at Human and Cyno GTR

[108] Jurkat human GTR/NFkB-Luc2 or Jurkat cyno GTR/NFkBLuc cells are starved overnight in assay media (RPMI1640 + 1% FBS) at 37°C, 5% CO₂ and resuspended the next day in assay media (RPMI1640 + 1% FBS) at 2e6 cells/mL. 50 µL/well of cell suspension is added to white opaque 96-well plates (Corning Costar) for 5e5 cells/well. 50
10 µL/well of 2X antibody dose titrations diluted in assay media are added and plates are incubated at 37°C, 5% CO₂ for 6 hours and then placed at room temperature for 15 minutes. 100 µL/well of BioGlo luciferase reagent (Promega) is added per well and incubated with shaking for 5 minutes at room temperature. Luminescence is measured with a BioTek SynergyNeo2 plate reader with Gen5 software. EC₅₀ values are calculated for GTR
15 antibody treatments from each of 2 or 3 experiment replicates and the EC₅₀ Geometric Error (delta method) is calculated from these results.

[109] Table 7: *In Vitro* GTR Antibody Agonism of Jurkat GTR/NFkB luciferase Cells.

Compound	Human GTR EC ₅₀ nM GeoMean	N	Cyno GTR IC ₅₀ nM GeoMean	N
Antibody I	no activity	3	no activity	3
Antibody II	no activity	3	no activity	3
Antibody III	8.50	2	0.52	2

20 [110] The luciferase reporter functional bioassay results in Table 7 demonstrate that treatment of Jurkat human GTR/NFkB luciferase or Jurkat cyno GTR/NFkB luciferase cells with Antibody I or Antibody II in the absence of GITRL did not result in agonist stimulation. In contrast, treatment with a bivalent IgG variant of Antibody I (i.e., Antibody III) did induce GTR pathway activation.

25

[111] Example 7: Antibody *In Vitro* Antagonism of GITRL co-stimulation of T cell proliferation.

[112] One aspect of GITRL biology is its ability to co-stimulate T cells, resulting in increased proliferation. In this example, it is demonstrated that Antibody I and Antibody II treatment potently inhibits plate-bound GITRL co-stimulation of human T cell proliferation. Human CD3⁺ T cells were isolated from peripheral blood mononuclear cells (PBMCs) and stimulated at 1.5e6 cells/mL with plate-bound 0.2 µg/mL anti-CD3 antibody for 4 days to increase GITR expression on T cells. T cells were then rested in culture medium for 2 days to prepare cells for restimulation. Activated and rested T cells at 1.5e6 cells/mL were then co-stimulated with plate-bound 2 µg/mL anti-CD3 antibody and 1 nM human GITRL for 5 days in the presence of Antibody I or Antibody II dose titrations. T cell proliferation was measured by H3-thymidine uptake during the last 18 hours of incubation. Each antibody was tested with triplicate dose titration conditions and tested on four different donors over three separate experiments.

[113] Table 8: In Vitro Potency of GITR Antagonist Antibodies for Inhibition of GITRL co-stimulation of T cell proliferation.

Compound	Human GITR IC ₅₀ nM GeoMean	Error (delta method)	N
Antibody I	4.76	1.42	4
Antibody II	1.84	0.52	4

[114] The GITRL co-stimulation assay results shown in Table 8 demonstrate that Antibody I and Antibody II potently inhibit GITRL co-stimulation of T cell proliferation. In contrast, an albVHH antibody fragment used as a negative control demonstrated negligible ability to inhibit GITRL co-stimulation of T cell proliferation (data not shown).

[115] Example 8: Antibody Restoration of *In Vitro* Regulatory T Cell Suppression of Effector T Cell Proliferation in the Presence of GITRL.

One aspect of GITRL biology is its ability to inhibit regulatory T cell suppression of effector T cell proliferation through binding and activation of GITR. In this example,

we demonstrate that Antibody I and Antibody II treatment potently restores the suppressive activity of regulatory T cells in the presence of plate-bound GITRL. Human T cells and CD4⁺CD127^{low}CD25⁺ regulatory T cells were isolated from peripheral blood mononuclear cells (PBMCs) and were labeled with CellTrace CFSE or CellTrace Violet (Invitrogen), respectively. T cells and CD4⁺CD127^{low}CD25⁺ regulatory T cells were combined at a 2:1 ratio in the presence of Antibody I or Antibody II dose titrations and stimulated with 2 µg/mL anti-CD28 and plate-bound 1 µg/mL anti-CD3 and 2 nM GITRL. After incubation for four days, proliferation of CD4⁺ T cells was evaluated by flow cytometry tracking CFSE labeling, excluding CellTrace Violet labeled CD4⁺CD127^{low}CD25⁺ regulatory T cells. The assay was performed with four individual donors on four separate occasions. 10,000 events were acquired per treatment (single biological replicate per antibody concentration tested) and used to calculate the percent proliferation of T effector cells.

[116] Table 9: *In Vitro* Potency of GITR Antagonist Antibodies for Restoration of Regulatory T cell Suppression of Effector T cell Proliferation in the presence of GITRL

Compound	Human GITR IC ₅₀ nM Mean	Error (delta method)	N
Antibody I	4.69	0.20	4
Antibody II	2.72	0.83	4

[117] The assay results shown in Table 9 demonstrate that Antibody I and Antibody II potently restore regulatory T cell suppression of effector T cell proliferation in the presence of GITRL.

[118] Example 9: Antibody Pharmacokinetics in Mice

[119] Male C57BL/6 mice are administered a single IV or SQ dose of 10 mg/kg of Antibody I or Antibody II in PBS (pH 7.4) at a volume of 0.1 mL/animal. For
5 pharmacokinetic characterization, blood is collected from 3 animals/group/timepoint at 1, 6, 24, 48, 72, 96, 120, 168, 240, and 336 hours post IV dose or at 3, 6, 12, 24, 48, 96, 120, 168, 240, and 336 hours post SQ dose and processed to plasma.

[120] Plasma concentrations of Antibodies I and II are determined by a plate-based GTR antigen capture enzyme-linked immunosorbent assay (ELISA) method. A
10 recombinant human GTR Fc chimera (rh GTR/TNFRSF18 Fc) is coated on the ELISA plate as a capture reagent at 1 mg/mL. After incubation with plasma standards, control and samples, a goat anti-human Ig Fab horseradish peroxidase is used to detect plate-bound Antibody I or Antibody II. Pharmacokinetic parameters are calculated using non-compartmental analysis (NCA) of mean concentrations determined at each time point (N=1
15 to 3 animals/group/time point). NCA is performed using Watson Bioanalytical LIMS. As shown in Table 10, Antibodies I and II demonstrate an extended pharmacokinetic profile in C57BL/6 mice.

[121] Table 10: Composite Plasma Pharmacokinetic Parameters for Antibodies I and II
20 Following a Single 10 mg/kg IV or SQ Dose to Male C57BL/5 Mice.

Antibody	Route	C ₀ (µg/mL)	C _{max} (µg/mL)	T _{max} (hr)	AUC _{0-inf} (hr*µg/mL)	CL or CL/F (mL/hr/kg)	t _{1/2} (hr)	%F
I	IV	86.8	NA	NA	5630	1.78	50.6	NA
I	SQ	NA	42.4	12	3270	3.06	40.7	58.1
II	IV	124	NA	NA	5430	1.84	29.3	NA
II	SQ	NA	69.2	12	3500	2.86	34.6	64.5

[122] Example 10: Antibody Pharmacokinetics in Rats

[123] Male Sprague Dawley rats are administered a single IV or SQ dose of 10 mg/kg Antibody I or Antibody II in PBS (pH 7.4) at volumes of 2.5 mL/kg and 1 mL/kg, respectively. For pharmacokinetic characterization, blood is collected from 3
5 animals/group/timepoint at 1, 6, 24, 48, 72, 96, 120, 168, 240, 336, 432 and 504 hours post IV dose or at 3, 6, 12, 24, 48, 96, 120, 168, 240, 336, 432 and 504 hours post SQ dose and processed to plasma.

[124] Plasma concentrations of Antibody Antibodies I and II are determined by a plate-based GTR antigen capture enzyme-linked immunosorbent assay (ELISA) method. A
10 recombinant human GTR Fc chimera (rh GTR/TNFRSF18 Fc) was coated on the ELISA plate as a capture reagent at 1 µg/mL. After incubation with plasma standards, control and samples, a goat anti-human Ig Fab horseradish peroxidase (diluted 1:10,000) was used to detect plate-bound Antibody I or Antibody II. Pharmacokinetic parameters are calculated using NCA for each animal (N=2-3) and parameters are summarized by the mean and
15 standard deviation (SD), where appropriate. Pharmacokinetic data were available for N=2 rats dosed subcutaneously with Antibody II and therefore mean parameters are reported. NCA and summary statistic calculations are performed using Watson Bioanalytical LIMS. As shown in Table 11 and Table 12, Antibody Antibodies I and II has demonstrate an extended pharmacokinetic profile in Sprague Dawley rats.

20

[125] Table 11: Plasma Pharmacokinetic Parameters for Antibody I Following a Single 10 mg/kg IV (N=3) or 10 mg/kg SQ (N=3) Dose to Male Sprague Dawley Rats.

Anti-body	Route	C ₀ (µg/mL)	C _{max} (µg/mL)	T _{max} (hr)	AUC _{0-inf} (hr*µg/mL)	CL or CL/F (mL/hr/kg)	t _{1/2} (hr)	%F
I	IV	289 (24.3)	NA	NA	14600 (1710)	0.69 (0.08)	54.0 (1.36)	NA
I	SQ	NA	48.8 (6.87)	48 (0)	6630 (267)	1.51 (0.06)	55.4 (1.99)	45.4

NOTE: Parameters are reported as mean (SD).

[126] Table 12: Plasma Pharmacokinetic Parameters for Antibody II Following a Single 10 mg/kg IV (N=3) or 10 mg/kg SQ (N=2) Dose to Male Sprague Dawley Rats.

Anti-body	Route	C ₀ (μg/mL)	C _{max} (μg/mL)	T _{max} (hr)	AUC _{0-inf} (hr*μg/mL)	CL or CL/F (mL/hr/kg)	t _{1/2} (hr)	%F
II	IV	188 (19.4)	NA	NA	10900 (473)	0.92 (0.04)	53.0 (6.90)	NA
II	SQ	NA	24.2	48	3540	2.86	55.6	32.5

NOTE: Parameters are reported as mean (SQ route) or mean (SD) (IV route).

5 [127] Example 11: Antibody Pharmacokinetics in Cynomolgus Monkey

[128] Cynomolgus monkeys are administered a single 0.1, 1, or 10 mg/kg IV dose or 10 mg/kg SQ dose of Antibody I or Antibody II in PBS (pH 7.2) at volumes of 1 mL/kg (IV) or 0.2 mL/kg (SC). For pharmacokinetic characterization, blood is collected from 3 animals/group/timepoint at 0.5, 3, 6, 24, 48, 72, 96, 168, 240, 336, 432, 504 and 672 hours post dose and processed to plasma.

[129] Plasma concentrations of Antibodies I and II are determined by plate-based GITR antigen capture enzyme-linked immunosorbent assay (ELISA) methods. A recombinant human GITR Fc chimera (rh GITR/TNFRSF18 Fc) is coated on the ELISA plate as a capture reagent at 1 μg/mL. After incubation with plasma standards, control and samples, 15 detections antibodies are used to determine the stability of the antibodies. In one method, a goat anti-human Ig Fab horseradish peroxidase is used to detect the Fab-portion of plate-bound Antibody I or Antibody II. In the second method, a Biotin-SP AffiniPure Goat Anti-Alpaca IgG, VHH domain is added as a secondary antibody to detect metabolically stable antibody with intact linker of plate-bound Antibody I or Antibody II. Following this 20 incubation, a peroxidase-conjugated streptavidin is added as a reagent to detect plate-bound Antibody I or Antibody II. Pharmacokinetic parameters are calculated using NCA for each animal and parameters are summarized by the mean and standard deviation (SD), where appropriate. NCA and summary statistic calculations are performed using Watson Bioanalytical LIMS. As shown in Table 13 and Table 14, Antibodies I and II demonstrate 25 an extended pharmacokinetic profile in cynomolgus monkeys. When comparing concentrations of Antibodies I or II measured with both ELISA methods, similar exposure

and pharmacokinetics was observed, indicating metabolic stability of these antibodies in vivo following IV or SQ administration.

[130] Table 13: Plasma Pharmacokinetic Parameters for Antibody I Following a Single 0.1 (N=1), 1 (N=2), or 10 mg/kg IV (N=2) or 10 mg/kg SQ (N=2) Dose to Cyno Monkeys.

ELISA Method	Route	Dose (mg/kg)	C ₀ (µg/mL)	C _{max} (µg/mL)	T _{max} (hr)	AUC _{0-inf} (hr*µg/mL)	CL or CL/F (mL/hr/kg)	t _{1/2} (hr)	%F
anti-Fab detection	IV	0.1	2.25	NA	NA	250	0.40	78.8	NA
	IV	1	42.2	NA	NA	6090	0.17	236	NA
	IV	10	386	NA	NA	47100	0.21	247	NA
	SQ	10	NA	106	72	33900	0.30	254	72
anti-VHH detection	IV	0.1	2.93	NA	NA	286	0.35	96.2	NA
	IV	1	35.1	NA	NA	4870	0.21	180	NA
	IV	10	282	NA	NA	41500	0.24	186	NA
	SQ	10	NA	117	48	34300	0.30	209	83

NOTE: Parameters are reported as mean.

[131] Table 14: Plasma Pharmacokinetic Parameters for Antibody II Following a Single 0.1 (N=2), 1 (N=2), or 10 mg/kg IV (N=2) or 10 mg/kg SQ (N=3) Dose to Cynomolgus Monkeys.

ELISA Method	Route	Dose (mg/kg)	C ₀ (µg/mL)	C _{max} (µg/mL)	T _{max} (hr)	AUC _{0-inf} (hr*µg/mL)	CL or CL/F (mL/hr/kg)	t _{1/2} (hr)	%F
anti-Fab detection	IV	0.1	2.47	NA	NA	189	0.54	82.9	NA
	IV	1	25.9	NA	NA	3280	0.32	194	NA
	IV	10	263	NA	NA	46500	0.22	291	NA
	SQ	10	NA	95.9 (12.7)	112 (111)	35600 (1760)	0.28 (0.01)	220 (64.3)	76.6
anti-VHH detection	IV	0.1	2.28	NA	NA	190	0.53	77.4	NA
	IV	1	27.6	NA	NA	3620	0.29	224	NA
	IV	10	349	NA	NA	38100	0.26	218	NA
	SQ	10	NA	99.9 (16.8)	64 (14)	34300 (5460)	0.30 (0.04)	194 (23.9)	90.0

NOTE: Parameters are reported as mean (IV route) or mean (SD) (SQ route).

Listing of Sequences**SEQ ID NO: 1 HCDR1**

5 AASGYTFSSYVMH

SEQ ID NO: 2 HCDR2.1

VTSYDGTHEY

10 **SEQ ID NO: 3 HCDR3**

ARENNWAPDY

SEQ ID NO: 4 LCDR1

RASQDISNSLA

15

SEQ ID NO: 5 LCDR2

YAAFSLQS

SEQ ID NO: 6 LCDR3

20 YQYYNYPSA

SEQ ID NO: 7 HCDR2.2

VTSYDGTHEL

25 **SEQ ID NO: 8 HC Variable Region (VH1)**

QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHEY YADSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARENNWAPDY
WGQGTLVTVSS

30 **SEQ ID NO: 9 HC Variable Region (VH2)**

QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHEL YADSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARENNWAPDY
WGQGTLVTVSS

5 **SEQ ID NO: 10 LC Variable Region (VL)**

DIQMTQSPSSLSASVGDRVTITCRASQDISNSLAWYQQKPGKAPKRLIYAAFSLQS
GVPSRFSGSGSGTEFTLTISLQPEDFATYYCYQYYNYPSAFGGGTKLEIK

SEQ ID NO: 11 Linker 1

10 DKTHTGGGGQGGGGQGGGGQGGGGQGGGGQ

SEQ ID NO: 12 Linker 2

DKTGGGGQGGGGQGGGGQGGGGQGGGGQ

15 **SEQ ID NO: 13 Albumin-binding VHH**

EVQLLES GGGLVQPGGSLRLSCAASGRYIDETAVAWFRQAPGKGREFVAGIGGG
VDITYYADSVKGRFTISRDN SKNTLYLQMNSLRPEDTAVYYCAARPGRPLITSKV
ADLYPYWGQGTLVTVSSPP

20 **SEQ ID NO: 14 HC anti-Fab - albumin-binding VHH Fusion 1**

QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHEY YADSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARENNWAPDY
WGQGTLVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSG
ALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVE
25 PKSCDKTHTGGGGQGGGGQGGGGQGGGGQGGGGQEVQLLES GGGLVQPGGSL
RLSCAASGRYIDETAVAWFRQAPGKGREFVAGIGGGVDITYYADSVKGRFTISRDN
SKNTLYLQMNSLRPEDTAVYYCAARPGRPLITSKVADLYPYWGQGTLVTVSSPP

30 **SEQ ID NO: 15 HC anti-GITR Fab - albumin-binding VHH Fusion 2**

QVQLVESGGGVVQPGRSLRLSCAASGYTFSSYVMHWVRQAPGKGLEWVAVTSY
DGTHEL YADSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARENNWAPDY

WGQGTLLTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSG
ALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVE
PKSCDKHTHTGGGGQGGGGQGGGGQGGGGQGGGGQEVQLLES GGGLVQPGGSL
RLSCAASGRYIDETAVAWFRQAPGKGREFVAGIGGGVDITYYADSVKGRFTISR
5 NSKNTLYLQMNSLRPEDTAVYYCAARPGRPLITSKVADLYPYWGQGTLLTVSSP
P

SEQ ID NO: 16 LC

DIQMTQSPSSLSASVGDRVTITCRASQDISNSLAWYQQKPGKAPKRLIYAAFSLQS
GVPSRFSGSGSGTEFTLTISSLQPEDFATYYCYQYYNYPSAFGQGTKLEIKRTVAA
10 PSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQD
SKDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO: 17 DNA Encoding HC anti-GITR Fab-albumin-binding VHH Fusion 1

CAAGTGCAGCTCGTGGAGTCGGGTGGCGGAGTGGTGCAGCCCGGAAGGTCCT
15 TGGCGCTCTCCTGTGCCGCTTCCGGCTACACCTTCTCGAGCTACGTGATGCAC
TGGGTCAGACAGGCACCGGGAAGGGTCTGGAATGGGTGGCCGTGACTTCCT
ACGACGGCACCCACGAGTATTACGCCGACTCAGTGAAGGGCCGCTTCACTAT
CTCCCGGGACAACCTCAAAGAACACCCTGTATCTGCAAATGAACTCACTGCGG
GCCGAGGACACTGCCGTGTACTACTGCGCGCGGAAAACAACCTGGGCCCTG
20 ACTACTGGGGACAGGGGACTCTGGTCACTGTGTCGTCCGCCTCGACCAAGGG
ACCCTCCGTGTTTCCGCTGGCGCCAAGCAGCAAGAGCACCTCGGGGGGAACT
GCAGCCTTGGGGTGCCTCGTGAAGGATTACTTCCCCGAACCAGTGACCGTGTC
CTGGAACCTCTGGGGCCCTCACCAGTGGAGTGCACACTTTCCTGCGGTGCTGC
AGTCCTCCGGAAGTGTACAGCCTGTCCAGCGTGGTACGGTGCCAGCTCCTCA
25 CTGGGCACCCAGACCTACATTTGCAACGTGAACCATAAGCCGTCCAATACCA
AAGTCGATAAGAAAGTCGAGCCGAAGTCCTGCGACAAGACACACACCGGTG
GAGGAGGCCAGGGTGGAGGTGGACAAGGCGGCGGAGGTCAAGGCGGAGGAG
GACAGGGTGGCGGAGGACAGGAAGTGCAGCTGCTGGAGTCCGGGGGCGGAC
TGGTGCAGCCTGGCGGATCATTGCGGCTGTCTGCGCGGCCTCCGGACGCTAC
30 ATCGACGAGACAGCAGTGGCCTGGTTCAGACAGGCTCCCGGAAAGGGAAGA
GAGTTCGTGGCCGGAATTGGCGGGGGAGTCGACATTACCTACTACGCCGATT
CCGTGAAGGGTCGCTTTACCATCTCCCGGGACAATTCAAGAACACCCTGTAC

CTCCAAATGAACTCGCTGAGGCCGGAAGATACCGCGGTGTATTACTGTGCCG
CCCGCCCGGGACGCCCGCTGATCACGTCCAAAGTCGCCGACCTGTACCCGTA
CTGGGGACAGGGTACCCTCGTGACCGTGTCCAGCCCTCCC

5 **SEQ ID NO: 18 DNA Encoding HC GITR- and albumin-binding VHH Fusion 2**

CAGGTGCAGCTCGTGGAGTCGGGTGGCGGAGTGGTGCAGCCCGGAAGGTCCT
TGCGGCTCTCCTGTGCCGCTTCCGGCTACACCTTCTCGAGCTACGTGATGCAC
TGGGTCAGACAGGCACCAGGAAAGGGTCTGGAATGGGTGGCCGTGACCTCCT
ACGACGGCACCCACGAGCTGTACGCCGACTCAGTGAAGGGCCGCTTCACTAT
10 CTCCCGGGACAACTCAAAGAACACCCTGTATCTGCAAATGAACTCACTGCGG
GCCGAGGACACTGCCGTGTACTACTGCGCGCGCGAAAATAACTGGGCCCCCTG
ACTACTGGGGACAGGGGACTCTGGTCACTGTGTCTCGTCCGCCTCGACCAAGGG
ACCCTCCGTGTTTCCGCTGGCGCCAAGCAGCAAGAGCACCTCGGGGGGAACT
GCAGCCTTGGGGTGCCCTCGTGAAGGATTACTTCCCCGAACCAGTGACCGTGTG
15 CTGGAACCTCTGGGGCCCTCACCAGTGGAGTGCACACTTTCCTGCGGTGCTGC
AGTCCTCCGGACTGTACAGCCTGTCCAGCGTGGTCACGGTGCCCAGCTCCTCA
CTGGGCACCCAGACCTACATTTGCAACGTGAACCATAAGCCGTCCAATACCA
AAGTCGATAAGAAAGTCGAGCCGAAGTCCTGCGACAAGACACACACCCGGTG
GAGGAGGCCAGGGTGGAGGTGGACAAGGCGGCGGAGGTCAAGGCGGAGGAG
20 GACAGGGTGGCGGAGGACAGGAAGTGCAGCTGCTGGAGTCCGGGGGCGGAC
TGGTGCAGCCTGGCGGATCATTGCGGCTGTCTGCGCGGCCTCCGGACGCTAC
ATCGACGAGACAGCAGTGGCCTGGTTCAGACAGGCTCCCGGAAAGGGAAGA
GAGTTCGTGGCCGGAATTGGCGGGGGAGTCGACATTACCTACTACGCCGATT
CCGTGAAGGGTCGCTTTACCATCTCCCGGGACAATTCGAAGAACACCCTGTAC
25 CTCCAAATGAACTCGCTGAGGCCGGAAGATACCGCGGTGTATTACTGTGCCG
CCCGCCCGGGACGCCCGCTGATCACGTCCAAAGTCGCCGACCTGTACCCGTA
CTGGGGACAGGGTACCCTCGTGACCGTGTCCAGCCCTCCC

SEQ ID NO: 19 DNA Encoding LC

30 GATATCCAGATGACCCAGTCCCCGAGCTCGCTGTCCGCTTCCGTGGGAGACA
GAGTGACGATCACTTGTCGGGCCAGCCAAGACATTAGCAACTCCCTGGCCTG
GTACCAGCAGAAGCCCGGCAAAGCACCCAAGAGGTTGATCTACGCGGCCTTT

TCACTGCAATCCGGAGTGCCGAGCCGGTTCTCCGGATCCGGTTCAGGGACCG
AGTTCACCTTGACCATTAGCAGCCTGCAGCCCGAAGATTTGCCACTTACTAC
TGCTACCAGTATTACAATTACCCATCGGCGTTCGGCCAAGGCACCAAGCTCGA
GATCAAGCGGACCGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATG
5 AGCAGTTGAAATCTGGAAGTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTAT
CCCAGAGAGGCCAAAGTACAGTGGAAGGTGGATAACGCCCTCCAATCGGGTA
ACTCCCAGGAGAGTGTACAGAGCAGGACAGCAAGGACAGCACCTACAGCCT
CAGCAGCACCTGACGCTGAGCAAAGCAGACTACGAGAAACACAAAGTCTAC
GCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCA
10 ACAGGGGAGAGTGC

SEQ ID NO: 20 Human GITR Full-length (w/o signal peptide)

QRPTGGPGCGPGRLLLGTGTDARCCRVHTTRCCRDYPGEECCSEWDCMCVQPEF
HCGDPCCTTCRHHPCPPGQGVQSQGKFSFGFQCIDCASGTFSGGHEGHCKPWTD
15 CTQFGFLTVPNGKTHNAVCPGSPPAEPLGWLTVVLLAVAACVLLLTSAQLGL
HIWQLRSQCMWPRETQLLLEVPPSTEDARSCQFPEEERGERSAEEKGRLGDLWV

SEQ ID NO: 21 Human GITR ECD (w/o signal peptide)

QRPTGGPGCGPGRLLLGTGTDARCCRVHTTRCCRDYPGEECCSEWDCMCVQPEF
20 HCGDPCCTTCRHHPCPPGQGVQSQGKFSFGFQCIDCASGTFSGGHEGHCKPWTD
CTQFGFLTVPNGKTHNAVCPGSPPAE

SEQ ID NO: 22: Signal Peptide amino acid sequence

METDTLLLWVLLLVPGSTG
25

CLAIMS:

1. A compound comprising X, an antigen binding fragment that binds human GITR (SEQ ID NO: 20) and comprises a heavy chain variable region (VH) and a light chain variable region (VL), wherein the VH comprises heavy chain complementarity determining regions HCDR1, HCDR2, and HCDR3, and the VL comprises light chain complementarity determining regions LCDR1, LCDR2, and LCDR3, wherein
 - i. the HCDR1 comprises SEQ ID NO: 1,
 - ii. the HCDR2 comprises SEQ ID NO: 2 or SEQ ID NO: 7,
 - iii. the HCDR3 comprises SEQ ID NO: 3,
 - iv. the LCDR1 comprises SEQ ID NO: 4,
 - v. the LCDR2 comprises SEQ ID NO: 5, and
 - vi. the LCDR3 comprises SEQ ID NO: 6.
2. The compound of claim 1 having the formula:
X-L-M or M-L-X,
wherein M is a VHH moiety that binds to human serum albumin; and
wherein L (if present) is a linker.
3. The compound of claim 2, wherein the VHH moiety comprises SEQ ID NO: 13, or an amino acid sequence having at least about 90% to about 99% sequence similarity thereto.
4. The compound of any one of claims 2-3, wherein the VHH moiety is fused to the C-terminus of the heavy chain first constant domain (CH1) of the Fab fragment via L.
5. The compound of any one of claims 1-4, wherein X comprises a VL having SEQ ID NO: 10.
6. The compound of any one of claims 1-5, wherein X comprises a VH having SEQ ID NO: 8 or a VH having SEQ ID NO: 9.
7. The compound of any one of claims 2-6, wherein L comprises a peptide linker selected from the group consisting of SEQ ID NO: 11, SEQ ID NO: 12, and SEQ ID NO: 23.

8. The compound of any one of claims 1-7, wherein X comprises a light chain (LC) as shown in SEQ ID NO: 16.
9. The compound of any one of claims 1-8, wherein X comprises a HC as shown in SEQ ID NO: 14 or a HC as shown in SEQ ID NO: 15.
- 5 10. A nucleic acid comprising SEQ ID NO: 17.
11. A nucleic acid comprising SEQ ID NO: 18.
12. A nucleic acid comprising SEQ ID NO: 19.
13. A vector comprising a nucleic acid as shown in SEQ ID NO: 17, SEQ ID NO: 18, or SEQ ID NO: 19.
- 10 14. A cell comprising the vector of claim 12.
15. A process of producing a compound comprising culturing the cell of claim 13 under conditions such that the antibody is expressed and recovering the expressed antibody from the culture medium.
16. A compound produced by the process of claim 14.
- 15 17. A pharmaceutical composition comprising the compound of any one of claims 1-9, and a pharmaceutically acceptable excipient, diluent or carrier.
18. A method of treating a GITR associated disorder by inhibiting GITR activities in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of the compound of any one of claims 1-9, or the pharmaceutical composition of claim 17.
- 20 19. The method of claim 18, wherein the GITR associated disorder is an autoimmune disorder, allergic disease, asthma, atopic dermatitis (AtD), inflammatory disorder, joint inflammation, arthritis, rheumatoid arthritis (RA), inflammatory bowel disease (IBD), Crohn's disease (CD) or ulcerative colitis (UC).
- 25 20. The compound of any one of claims 1-9 for use in therapy.
21. The compound of any one of claims 1-9 for use in the treatment of an autoimmune disorder, allergic disease, asthma, AtD, inflammatory disorder, joint inflammation, arthritis, RA, IBD, CD or UC.
22. Use of the compound of claim 20 or 21, in the manufacture of a medicament for the treatment of an autoimmune disorder, allergic disease, asthma, AtD, inflammatory disorder, joint inflammation, arthritis, rheumatoid arthritis, IBD, CD or UC.
- 30