

ANTIBODIES THAT SPECIFICALLY BIND TO TL1A

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/220,442, filed on September 18, 2015, the contents of which are incorporated by reference herein, in their entirety and for all purposes.

REFERENCE TO A SEQUENCE LISTING

This application includes a Sequence Listing submitted electronically as a text file named TL1A_ST25, created on September 18, 2015 with a size of 89,000 bytes. The Sequence Listing is incorporated by reference herein.

FIELD OF THE INVENTION

This disclosure relates generally to the field of antibody engineering. More specifically, this disclosure relates to variant antibodies that bind specifically to TL1A, and which inhibit the interaction between TL1A and the death receptor 3 (DR3). In some aspects, the antibodies also inhibit the interaction between TL1A and the decoy receptor 3 (DcR3). The antibodies have improved potency relative to the parent antibody from which the variants were derived.

BACKGROUND OF THE INVENTION

Various publications, including patents, published applications, accession numbers, technical articles and scholarly articles are cited throughout the specification. Each of these cited publications is incorporated by reference, in its entirety and for all purposes, in this document.

TNF-like ligand 1A (TL1A, syn. TNF superfamily member 15 (TNFSF15); TL1 and VEGI) is a member of the tumor necrosis factor superfamily, which is expressed by antigen presenting cells (including dendritic cells, B cells and macrophages), CD4+ and CD8+ T cells and endothelial cells. TL1A can be expressed on the cell surface or secreted as a soluble cytokine. The receptor for TL1A, Death Receptor 3 (DR3) is expressed by a variety of cells, including CD4+ and CD8+ T cells, NK cells, NKT cells and FOXP3+ regulatory T (Treg) cells and type-2 and type-3 innate lymphoid cells (ILC2 and ILC3).

TL1A can also bind a decoy receptor (DcR3), which is a competitive inhibitor of DR3. DcR3 also acts as a decoy receptor for Fas-ligand (Fas-L) and lymphotoxin-like inducible

protein that competes with glycoprotein D for binding herpesvirus entry mediator on T-cells (LIGHT). Accordingly, DcR3 is an important regulator of several signal transduction pathways.

The TL1A/DR3 signalling pathway has been implicated in several biological systems, which are associated with human diseases. For example, TL1A has been shown to play a role in immunity, angiogenesis, and homeostasis of barrier tissues. Inhibiting TL1A interaction with DR3 also has been shown to promote a therapeutic benefit in several immune-mediated conditions, such as experimental autoimmune encephalomyelitis (EAE; a model of multiple sclerosis), colitis, ulcerative colitis, Crohn's disease, inflammatory bowel disease, skin disease, asthma and arthritis.

Accordingly, compounds that inhibit TL1A activity are desirable, *e.g.*, for their therapeutic, prophylactic, diagnostic and prognostic uses.

SUMMARY

Provided herein is a recombinant antibody comprising a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 28, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 29, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 30, provided that when the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, the light chain variable region does not comprise the amino acid sequence of SEQ ID NO: 2.

In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 16, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 20. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 16, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 23, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the

amino acid sequence of SEQ ID NO: 16, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 24, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 16, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 25, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 16, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 26, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21 and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 24, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 25, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 26, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22. In some embodiments, the antibody comprises a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 27.

Disclosed herein is a recombinant antibody, comprising a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 18, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable

region CDR3 comprising the amino acid sequence of SEQ ID NO: 22, wherein the antibody specifically binds to TNF-like ligand 1A (TL1A).

Also provided herein is a recombinant antibody comprising a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 or SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 14, provided that when the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, the light chain variable region does not comprise the amino acid sequence of SEQ ID NO: 2. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 6. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 7. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 8. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 6. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 7. In some embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 8. In some

embodiments, the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 10.

In some embodiments, the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 60. In some embodiments, the antibody comprises a light chain comprising the amino acid sequence of SEQ ID NO: 61. In some embodiments, the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 60 and a light chain comprising the amino acid sequence of SEQ ID NO: 61.

Such recombinant antibodies preferably are full length, and preferably are monoclonal. Such recombinant antibodies bind to TL1A with enhanced affinity relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. Such recombinant antibodies have enhanced potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 10-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 12-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 13-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 15-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 20-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 25-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1

and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 27-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 40-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. Fold-enhancement of potency may be determined according to a TL1A-induced caspase potency assay in TF-1 cells.

Such recombinant antibodies may comprise a human IgG1 heavy chain constant region, a human IgG2 heavy chain constant region, or a human IgG4 heavy chain constant region, or any allotypes thereof. The human IgG1 heavy chain constant region may comprise SEQ ID NO: 42, or SEQ ID NO: 43 (human IgG1 Δ K), or SEQ ID NO: 44 (human IgG1 with YTE), or SEQ ID NO: 64 (human IgG1 with YTE and Δ K), or SEQ ID NO: 63 (human IgG1 with L234A, L235A, G237A) or SEQ ID NO: 62 (human IgG1 with L234A, L235A, G237A and Δ K), or SEQ ID NO: 65 (human IgG1 with L235A and G237A) or SEQ ID NO: 66 (human IgG1 with L235A, G237A and Δ K). The human IgG2 heavy chain constant region may comprise SEQ ID NO: 67, or SEQ ID NO: 70 (human IgG2 Δ K), or SEQ ID NO: 71 (human IgG2 with A330S, P331S), or SEQ ID NO: 68 (human IgG2 with A330S, P331S and Δ K). The human IgG4 heavy chain constant region may comprise SEQ ID NO: 45, or SEQ ID NO: 46 (human IgG4 with S228P and Δ K), or SEQ ID NO: 47 (human IgG4 with S228P and YTE), or SEQ ID NO: 69 (human IgG4 with S228P, YTE and Δ K). It will be understood that an IgG4 heavy chain could be used without the stabilizing substitution S228P (*e.g.*, IgG4 with YTE alone, or IgG4 with YTE and Δ K, or IgG4 with Δ K alone).

The recombinant antibodies may comprise a human lambda light chain constant region or an allotype thereof. The human light chain lambda constant region may comprise SEQ ID NO: 48.

Such recombinant antibodies bind to human TL1A, and may bind to the TL1A of a non-human primate, or the TL1A of a non-human mammal such as a mouse, rat, guinea pig, cat, dog, rabbit, or pig.

Such recombinant antibodies may be used in a method for treating a respiratory tract disease, a method for treating a gastrointestinal disease, a method of treating a skin

disease, or a method of treating arthritis, or may be for use in the treatment of a respiratory tract disease, a gastrointestinal disease, a skin disease, or arthritis, or may be for use in the manufacture of a medicament for the treatment of a respiratory tract disease, a gastrointestinal disease, a skin disease, or arthritis. The respiratory tract disease may comprise one or more of asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pulmonary sarcoidosis, allergic rhinitis, or cystic fibrosis. The gastrointestinal disease may comprise one or more of inflammatory bowel disease, Crohn's disease, colitis, ulcerative colitis, eosinophilic esophagitis, or irritable bowel syndrome, or a gastrointestinal disease or condition associated with cystic fibrosis. The arthritis may comprise rheumatoid arthritis. The skin disease may comprise one or more of atopic dermatitis, eczema, and scleroderma.

Disclosed herein is a composition, comprising the recombinant antibody as defined herein and a pharmaceutically acceptable carrier, wherein the composition is formulated for administration to a human subject.

Human subjects, non-human primate subjects, or non-human mammalian subjects in need of such treatments may be treated with the antibodies or a composition comprising the antibodies, for example, by administering the antibodies or composition thereof to the subject. Administration may be parenteral, for example, subcutaneous and/or intravenous.

Disclosed herein is the use of a composition comprising the recombinant antibody as defined herein and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a respiratory tract disease selected from asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pulmonary sarcoidosis, allergic rhinitis, and cystic fibrosis, wherein the medicament is formulated for administration to a human subject.

Disclosed herein is the use of a composition comprising the recombinant antibody as defined herein and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a gastrointestinal disease selected from inflammatory bowel disease, Crohn's disease, colitis, ulcerative colitis, eosinophilic esophagitis, irritable bowel syndrome, and gastrointestinal disease associated with cystic fibrosis, wherein the medicament is formulated for administration to a human subject.

Disclosed herein is the use of a composition comprising the recombinant antibody as defined herein and a pharmaceutically acceptable carrier in the manufacture of a

medicament for treating arthritis, wherein the medicament is formulated for administration to a human subject.

Disclosed herein is the use of a composition comprising the recombinant antibody as defined herein and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a skin disease selected from atopic dermatitis, eczema, and scleroderma, wherein the medicament is formulated for administration to a human subject.

Such recombinant antibodies may be used in a method for detecting TL1A on the surface of peripheral blood mononuclear cells (PBMCs). The methods comprise contacting an antibody that binds to TL1A as described or exemplified herein with PBMCs obtained from a subject, and detecting the antibody bound to TL1A on the surface of the PBMCs. The methods may further comprise quantifying the level of TL1A on the PBMCs. The methods may further comprise obtaining the PBMCs from the subject.

Disclosed herein is an *in vitro* method of detecting TL1A in a sample obtained from a subject comprising contacting the sample with the antibody as defined herein and detecting the antibody bound to TL1A in the sample.

Such recombinant antibodies may be used in a method for detecting TL1A in blood serum. The methods comprise contacting an antibody that binds to TL1A as described or exemplified herein with blood serum obtained from a subject, and detecting the antibody bound to TL1A in the serum. The methods may further comprise quantifying the level of TL1A in the blood serum. The methods may further comprise obtaining the serum from blood obtained from the subject. The methods may further comprise obtaining blood from the subject.

Polynucleotides encoding one or more of the heavy chain variable region and the light chain variable region of such antibodies are provided. The polynucleotides may further encode a heavy chain constant region and/or a light chain constant region.

Disclosed herein is a polynucleotide comprising a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO:3.

Disclosed herein is a polynucleotide comprising a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO:4.

In some embodiments, a polynucleotide comprises a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, for example, a nucleic acid sequence comprising SEQ ID NO: 51 or SEQ ID NO: 58. In some

embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 2, for example, a nucleic acid sequence comprising SEQ ID NO: 50. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 4, for example, a nucleic acid sequence comprising SEQ ID NO: 52 or SEQ ID NO: 59. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 6, for example, a nucleic acid sequence comprising SEQ ID NO: 54. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 7, for example, a nucleic acid sequence comprising SEQ ID NO: 55. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 8, for example, a nucleic acid sequence comprising SEQ ID NO: 56. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 10, for example, a nucleic acid sequence comprising SEQ ID NO: 57.

In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1, for example, a nucleic acid sequence comprising SEQ ID NO: 49. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 4, for example, a nucleic acid sequence comprising SEQ ID NO: 52. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 5, for example, a nucleic acid sequence comprising SEQ ID NO: 53. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 6, for example, a nucleic acid sequence comprising SEQ ID NO: 54. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 7, for example, a nucleic acid sequence comprising SEQ ID NO: 55. In some embodiments, the polynucleotide comprises a nucleic acid sequence encoding an antibody

light chain variable region comprising the amino acid sequence of SEQ ID NO: 8, for example, a nucleic acid sequence comprising SEQ ID NO: 56.

Vectors comprising one or more of such polynucleotides are provided. Cells transformed with one or more such polynucleotides or such vectors are provided. Transformed cells may be mammalian, and preferably are mammalian expression host cells such as CHO cells, NS0 cells, or HEK293 cells.

Disclosed herein is a host cell comprising a vector comprising the polynucleotide as defined herein.

Disclosed herein is a transformed host cell that comprises a polynucleotide encoding the antibody as defined herein and which expresses said antibody.

Disclosed herein is method of making an antibody comprising culturing the host cell as defined herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the positions and identities of each of the single amino acid substitutions made to the CDR1 or CDR2 regions or to selected amino acid residues adjacent to CDR2 of the parent antibody (320-179) variable heavy chain. Boxed regions represent the CDRs according to the AbM numbering system.

Figure 2 shows the positions and the identities of each of the single amino acid substitutions made to the CDR1 or CDR3 regions of the parent antibody (320-179) variable light chain. Boxed regions represent the CDRs according to the AbM numbering system.

Figure 3 shows an alignment of variant anti-TL1A-antibody heavy chains.

Figure 4 shows an alignment of variant anti-TL1A-binding antibody light chains.

Figure 5 shows a comparison of the TL1A dissociation phase of variant anti-TL1A antibodies, as measured by SPR.

Figure 6 shows the results of TF-1 cell caspase potency assays with variant TL1A antibodies.

Figure 7 shows the results of TF-1 cell caspase potency assays using various TL1A antibodies compared to the parent antibody, 320-179.

Figure 8 shows that antibody 320-587 has superior TL1A potency in a TF-1 cell caspase potency assay, compared to other published anti-TL1A antibodies across several different experiments.

Figure 9 shows various anti-TL1A antibodies that inhibit TL1A binding to DR3, as compared to an isotype control as measured in ELISA format.

Figure 10 shows that the parent antibody, 320-179, does not inhibit TL1A binding to DcR3 while the variant anti-TL1A antibodies do inhibit the TL1A-DcR3 interaction.

Figure 11 shows that antibody 320-587 cross reacts with and binds to TL1A of different species; the antibody bound to TL1A from all species tested.

Figure 12 shows the results of the administration of antibody 320-587 in a rat TNBS-induced colitis model, demonstrating that the antibody significantly ameliorates symptoms of colitis

Figure 13 shows that antibody 320-587 detects human TL1A secreted from human PBMCs stimulated with immune complexes, in an ELISA test.

Figure 14 shows that antibody 320-587 detects a population of human PBMCs that express membrane TL1A on their surface, in a flow cytometry test.

Figure 15 shows that rats having acute OVA-induced asthma treated with antibody 320-587 had significantly reduced eosinophils in the bronchoalveolar lavage fluid (BALF).

Figures 16A through 16D show treatment of guinea pigs having acute OVA-induced asthma treated with antibody 320-587 had improvements in (Fig. 16A) BALF eosinophils, (Fig. 16B) BALF macrophages, (Fig. 16C) Airways hyper responsiveness after early asthmatic reaction, and (Fig. 16D) Magnitude of early asthmatic reaction.

Figures 17A through 17E show treatment of rats having chronic OVA-induced asthma treated with antibody 320-587 had improvements in (Fig. 17A) BALF eosinophils, (Fig. 17B) BALF macrophages, (Fig. 17C) BALF IL-13, (Fig. 17D) goblet cell hyperplasia as assessed by PAS reactivity, and (Fig. 17E) mucosal thickening as assessed from H&E stained sections.

Figure 18 shows the dose of ovalbumin required to double airways obstruction.

Figure 19 shows treatment of rats having TNBS-induced colitis treated with antibody 320-587 had improvements in ulcer area fibrosis.

Figures 20A through 20E show a comparison of rats having TNBS-induced colitis with DNBS-induced colitis, treated with antibody 320-587 and the effects at 7 and 14 days, on (Fig. 20A) colon weight/length ratio, (Fig. 20B) colon fibrosis, (Fig. 20C) colon infiltrate, and (Fig. 20D) colon damage. Fig. 20E shows representative sections of ulcer area at 7 and 14 days.

Figures 21A through 21C show treatment of rats having DSS-induced colitis treatment with antibody 320-587 had improvements in (Fig. 21A) weight change during DSS administration, (Fig. 21B) Clinical scoring during DSS administration, and (Fig. 21C) colon weight/length ratio.

Figure 22 shows changes in TL1A-induced intraperitoneal cytokines in response to 320-587 treatment.

DETAILED DESCRIPTION OF THE INVENTION

Various terms relating to aspects of disclosure are used throughout the specification and claims. Such terms are to be given their ordinary meaning in the art, unless otherwise indicated. Other specifically defined terms are to be construed in a manner consistent with the definition provided herein.

The terms “subject” and “patient” are used interchangeably and include any animal. Mammals are preferred, including companion (*e.g.*, cat, dog) and farm mammals (*e.g.*, pig, horse, cow), as well as rodents, including mice, rabbits, and rats, guinea pigs, and other rodents. Non-human primates, such as cynomolgus monkeys, are more preferred, and human beings are highly preferred.

A molecule such as an antibody has been “isolated” if it has been altered and/or removed from its natural environment by the hand of a human being.

As used herein, the singular forms “a,” “an,” and “the” include plural referents unless expressly stated otherwise.

“Specificity” in the context of antibody-antigen interactions is not necessarily an absolute designation but may constitute a relative term signifying the degree of selectivity of an antibody for an antigen-positive cell compared to an antigen-negative cell. Specificity of an antibody for an antigen-positive cell is mediated by the variable regions of the antibody, and usually by the complementarity determining regions (CDRs) of the antibody. A construct may have from about 100 to about 1000-fold specificity for antigen-positive cells compared to antigen-negative cells.

As used herein, the term “recombinant” includes the expression from genes made by genetic engineering or otherwise by laboratory manipulation.

The disclosure provides variant anti-TL1A antibodies comprising a recombinantly altered heavy and/or light chain variable region of antibody 320-179, which variant antibodies specifically bind to TL1A. These 320-179 variant antibodies inhibit the capability

of TL1A to interact with DR3 and, in some aspects, also with DcR3 and, further inhibit the signalling induced by the interaction of TL1A with DR3. These antibodies have enhanced potency relative to antibody 320-179. These antibodies have enhanced affinity for TL1A relative to antibody 320-179.

The enhanced potency may be at least about 10-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 12-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 13-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 15-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 20-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 25-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 27-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. The enhanced potency may be at least about 40-fold greater potency relative to an antibody having a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. Fold-enhancement of potency may be determined, for example, by measuring caspase release in TL1A-induced apoptosis in a TF-1 cell assay.

The 320-179 variant antibodies are recombinantly expressed, and specifically bind to TL1A. The parent antibody, 320-179, comprises a heavy chain variable region comprising

the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. In some aspects, a 320-179 variant antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 or SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 14, provided that when the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, the light chain variable region does not comprise the amino acid sequence of SEQ ID NO: 2. The 320-179 variant antibody is capable of inhibiting the interaction of TL1A with DR3. The 320-179 variant antibody has enhanced potency relative to antibody 320-179 and/or has enhanced affinity for TL1A relative to antibody 320-179.

In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 4. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 2. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 5. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 6. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 7. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 8. In some highly preferred aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 4. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 6. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 7. In some aspects, the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 8. In some aspects, the

heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 3, and the light chain variable region comprises the amino acid sequence of SEQ ID NO: 10.

In highly preferred aspects, the 320-179 variant antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3, and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4, and specifically binds to TL1A. In some aspects, the heavy chain variable region of SEQ ID NO: 3 is joined to a human IgG1(Δ K) heavy chain constant region (e.g., SEQ ID NO: 43) such that the heavy chain comprises SEQ ID NO: 60. In some aspects, the light chain variable region of SEQ ID NO: 4 is joined to a lambda human light chain constant region (e.g., SEQ ID NO: 48) such that the light chain comprises SEQ ID NO: 61. The 320-179 variant antibody is capable of inhibiting the interaction of TL1A with DR3. The variant antibody has enhanced potency relative to antibody 320-179 and/or has enhanced affinity for TL1A relative to antibody 320-179.

In some aspects, the 320-179 variant antibodies are recombinantly expressed and specifically bind to TL1A, and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 28, and a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17. The antibodies may comprise a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 29, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 30. In aspects where the heavy chain variable region comprises the amino acid sequence of SEQ ID NO: 1, the light chain variable region preferably does not comprise the amino acid sequence of SEQ ID NO: 2. These 320-179 variant antibodies are capable of inhibiting the interaction of TL1A with DR3. These 320-179 variant antibodies have enhanced potency relative to antibody 320-179 and/or have enhanced affinity for TL1A relative to antibody 320-179.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 16, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 18, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 26, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 18, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 24, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 25, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 26, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22.

In some aspects, the antibodies specifically bind to TL1A and comprise a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 18, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 27.

In some aspects, the antibodies specifically bind to TL1A, and comprise a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region, provided that the light chain variable region does not comprise the amino acid sequence of SEQ ID NO: 2. In some aspects, the antibodies specifically bind to TL1A, and comprise a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region or a light chain. The light chain variable region may further comprise a lambda constant region.

In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2 and a heavy chain variable region, provided that the heavy chain variable region does not comprise the amino acid sequence of SEQ ID NO: 1. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 6 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 7 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 8 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 9 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 10 and a heavy chain variable region. In

some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 11 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 12 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 13 and a heavy chain variable region. In some aspects, the antibodies specifically bind to TL1A, and comprise a light chain variable region comprising the amino acid sequence of SEQ ID NO: 14 and a heavy chain variable region, provided that if the light chain variable region comprises the amino acid sequence of SEQ ID NO: 2, the heavy chain variable region does not comprise the amino acid sequence of SEQ ID NO: 1. The heavy chain variable region may further comprise a heavy chain constant region, including any IgG1, IgG2, or IgG4 heavy chain constant region amino acid sequence described or exemplified herein.

The 320-179-variant antibodies specifically bind to TL1A. The antibodies bind to human TL1A, and may bind to one or more of cynomolgus monkey TL1A, mouse TL1A, rat TL1A, guinea pig TL1A, cat TL1A, dog TL1A, pig TL1A, or rabbit TL1A. In some aspects, the antibodies may bind to TL1A of multiple different species, for example, if the epitope is shared. In some aspects, human TL1A comprises the amino acid sequence of SEQ ID NO: 31, SEQ ID NO: 32, or SEQ ID NO: 33. In some aspects, cynomolgus monkey TL1A comprises the amino acid sequence of SEQ ID NO: 34. In some aspects, mouse TL1A comprises the amino acid sequence of SEQ ID NO: 35. In some aspects, rat TL1A comprises the amino acid sequence of SEQ ID NO: 36. In some aspects, guinea pig TL1A comprises the amino acid sequence of SEQ ID NO: 37. In some aspects, cat TL1A comprises the amino acid sequence of SEQ ID NO: 38. In some aspects, pig TL1A comprises the amino acid sequence of SEQ ID NO: 39. In some aspects, rabbit TL1A comprises the amino acid sequence of SEQ ID NO: 40. In some aspects, dog TL1A comprises the amino acid sequence of SEQ ID NO: 41.

The 320-179-variant antibodies have a binding affinity for an epitope on TL1A that includes an equilibrium dissociation constant (K_D), which can be measured according to a kinetic exclusion assay, such as a KINEXA[®] assay (Sapidyne Instruments Inc., Boise, ID). The K_D for TL1A binding determined from a kinetic exclusion assay is preferably less than about 1000 pM. In some aspects, the K_D for TL1A binding determined from a kinetic exclusion assay is less than about 500 pM, or less than about 400 pM, or less than about 300

pM, or less than about 200 pM. In some preferred aspects, the K_D for TL1A binding determined from a kinetic exclusion assay is less than about 100 pM.

The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 10 pM to about 100 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 25 pM to about 75 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 30 pM to about 60 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 30 pM to about 50 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 35 pM to about 50 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 36 pM to about 46 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 38 pM to about 44 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 39 pM to about 43 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 40 pM to about 45 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be from about 35 pM to about 42 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be about 40 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be about 41 pM. The K_D for TL1A binding determined from a kinetic exclusion assay may be about 42 pM. The kinetic exclusion assay may use the antibody molecule or TL1A molecule as the constant binding partner, and the other molecule as the titrant.

The 320-179-variant anti-TL1A antibodies are preferably capable of binding to TL1A-positive cells. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 100 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 75 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 50 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 30 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 25 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 20 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 18 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 15 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 13 nM. The antibody may bind to a TL1A-positive cell with an EC_{50} value of less than about 10 nM.

The 320-179-variant antibodies preferably are monoclonal, and more preferably are full length antibodies comprising two heavy chains and two light chains. In some aspects, the antibodies comprise derivatives or fragments or portions of antibodies that retain the antigen-binding specificity, and also preferably retain most or all of the affinity, of the 320-179 parent antibody molecule (*e.g.*, for TL1A). For example, derivatives may comprise at least one variable region (either a heavy chain or light chain variable region). Other examples of suitable antibody derivatives and fragments include, without limitation, antibodies with polyepitopic specificity, bispecific antibodies, multi-specific antibodies, diabodies, single-chain molecules, as well as FAb, F(Ab')₂, Fd, Fab_c, and Fv molecules, single chain (Sc) antibodies, single chain Fv antibodies (scFv), individual antibody light chains, individual antibody heavy chains, fusions between antibody chains and other molecules, heavy chain monomers or dimers, light chain monomers or dimers, dimers consisting of one heavy and one light chain, and other multimers. Single chain Fv antibodies may be multi-valent. All antibody isotypes may be used to produce antibody derivatives, fragments, and portions. Antibody derivatives, fragments, and/or portions may be recombinantly produced and expressed by any cell type, prokaryotic or eukaryotic.

In a full-length antibody, each heavy chain is comprised of a heavy chain variable region (abbreviated herein as HCVR or VH) and a heavy chain constant region. The heavy chain constant region is comprised of three domains, CH1, CH2 and CH3. Each light chain is comprised of a light chain variable region (abbreviated herein as LCVR or VL) and a light chain constant region. The light chain constant region is comprised of one domain, CL. The VH and VL regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each VH and VL is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. Typically, the antigen binding properties of an antibody are less likely to be disturbed by changes to FR sequences than by changes to the CDR sequences. Immunoglobulin molecules can be of any type (*e.g.*, IgG, IgE, IgM, IgD, IgA and IgY), class (*e.g.*, IgG1, IgG2, IgG3, IgG4, IgA1 and IgA2) or subclass.

The 320-179-variant antibodies are fully human. Fully human antibodies are those where the whole molecule is human or otherwise of human origin, or includes an amino acid sequence identical to a human form of the antibody. Fully human antibodies include

those obtained from a human V gene library, for example, where human genes encoding variable regions of antibodies are recombinantly expressed. Fully human antibodies may be expressed in other organisms (*e.g.*, mice and xenomouse technology) or cells from other organisms transformed with genes encoding human antibodies. Fully human antibodies may nevertheless include amino acid residues not encoded by human sequences, *e.g.*, mutations introduced by random or site directed mutations.

In some aspects, the 320-179-variant antibodies may comprise non-immunoglobulin derived protein frameworks. For example, reference may be made to (Ku & Schutz, 1995, Proc. Natl. Acad. Sci. USA 92: 6552-6556) which describes a four-helix bundle protein cytochrome b562 having two loops randomized to create CDRs, which have been selected for antigen binding.

The 320-179-variant antibodies may comprise post-translational modifications or moieties, which may impact antibody activity or stability. These modifications or moieties include, but are not limited to, methylated, acetylated, glycosylated, sulfated, phosphorylated, carboxylated, and amidated moieties and other moieties that are well known in the art. Moieties include any chemical group or combinations of groups commonly found on immunoglobulin molecules in nature or otherwise added to antibodies by recombinant expression systems, including prokaryotic and eukaryotic expression systems.

Examples of side chain modifications contemplated by the disclosure include modifications of amino groups such as by reductive alkylation by reaction with an aldehyde followed by reduction with NaBH₄; amidination with methylacetimidate; acylation with acetic anhydride; carbamoylation of amino groups with cyanate; trinitrobenzylation of amino groups with 2, 4, 6-trinitrobenzene sulphonic acid (TNBS); acylation of amino groups with succinic anhydride and tetrahydrophthalic anhydride; and pyridoxylation of lysine with pyridoxal-5-phosphate followed by reduction with NaBH₄.

The guanidine group of arginine residues may be modified by the formation of heterocyclic condensation products with reagents such as 2,3-butanedione, phenylglyoxal and glyoxal. The carboxyl group may be modified by carbodiimide activation via O-acylisourea formation followed by subsequent derivation, for example, to a corresponding amide. Sulfhydryl groups may be modified by methods such as carboxymethylation with iodoacetic acid or iodoacetamide; performic acid oxidation to cysteic acid; formation of

mixed disulfides with other thiol compounds; reaction with maleimide, maleic anhydride or other substituted maleimide; formation of mercurial derivatives using 4-chloromercuribenzoate, 4-chloromercuriphenylsulfonic acid, phenylmercury chloride, 2-chloromercuri-4-nitrophenol and other mercurials; carbamoylation with cyanate at alkaline pH. Tryptophan residues may be modified by, for example, oxidation with N-bromosuccinimide or alkylation of the indole ring with 2-hydroxy-5-nitrobenzyl bromide or sulfonyl halides. Tyrosine residues on the other hand, may be altered by nitration with tetranitromethane to form a 3-nitrotyrosine derivative. Modification of the imidazole ring of a histidine residue may be accomplished by alkylation with iodoacetic acid derivatives or N-carbethoxylation with diethylpyrocarbonate.

The 320-179-variant antibodies may include modifications that modulate serum half-life and biodistribution, including without limitation, modifications that modulate the antibody's interaction with the neonatal Fc receptor (FcRn), a receptor with a key role in protecting IgG from catabolism, and maintaining high serum antibody concentration. Serum half-life modulating modifications may occur in the Fc region of IgG1, IgG2, or IgG4, including the triple substitution of M252Y/S254T/T256E (the "YTE" substitutions, with numbering according to the EU numbering system (Edelman, G.M. *et al.* (1969) Proc. Natl. Acad. USA 63, 78-85)), as described in U.S. Pat. No. 7,083,784. Other substitutions may occur at positions 250 and 428, *see e.g.*, U.S. Pat. No 7,217,797, as well as at positions 307, 380 and 434, *see, e.g.*, PCT Publ. No. WO 00/042072. Examples of constant domain amino acid substitutions which modulate binding to Fc receptors and subsequent function mediated by these receptors, including FcRn binding and serum half-life, are described in U.S. Publ. Nos. 2009/0142340, 2009/0068175, and 2009/0092599. Antibodies of any class may have the heavy chain C-terminal lysine omitted or removed to reduce heterogeneity (Δ K). The substitution of S228P (EU numbering) in the human IgG4 can stabilize antibody Fab-arm exchange *in vivo* (Labrin *et al.* (2009) Nature Biotechnology 27:8; 767-773), and this substitution may be present at the same time as the YTE and/or Δ K modifications.

The 320-179-variant antibodies comprise human constant domains. The heavy chain constant domains preferably are human IgG1, IgG2, or IgG4 constant domains. The light chain constant domains preferably are human lambda constant domains. A suitable human lambda domain comprises SEQ ID NO: 48.

Human heavy chain IgG1 constant regions that may be used with the 320-179 variant antibodies may be selected from among human IgG1 (SEQ ID NO: 42), human IgG1 (Δ K) (SEQ ID NO: 43), human IgG1 252Y/254T/256E (SEQ ID NO: 44), human IgG1 252Y/254T/256E (Δ K) (SEQ ID NO: 64), human IgG1 L234A/L235A/G237A (SEQ ID NO: 63), human IgG1 L234A/L235A/G237A (Δ K) (SEQ ID NO: 62), human IgG1 L235A/G237A (SEQ ID NO: 65), and human IgG1 L235A/G237A (Δ K) (SEQ ID NO: 66). Human heavy chain IgG2 constant regions that may be used with the 320-179 variant antibodies may be selected from among human IgG2 with or without Δ K (SEQ ID NO: 67 and SEQ ID NO: 70) and human IgG2 A330S/P331S with or without (Δ K) (SEQ ID NO: 71 and SEQ ID NO: 68). Human heavy chain IgG4 constant regions that may be used with the 320-179 variant antibodies may be selected from among human IgG4 S228P (SEQ ID NO: 45), human IgG4 S228P (Δ K) (SEQ ID NO: 46), human IgG4 228P/252Y/254T/256E (SEQ ID NO: 47), and human IgG4 228P/252Y/254T/256E (Δ K) (SEQ ID NO: 69).

The 320-179-variant antibodies may be labelled, bound, or conjugated to any chemical or biomolecule moieties. Labelled antibodies may find use in therapeutic, diagnostic, or basic research applications. Such labels/conjugates can be detectable, such as fluorochromes, electrochemiluminescent probes, quantum dots, radiolabels, enzymes, fluorescent proteins, luminescent proteins, and biotin. The labels/conjugates may be chemotherapeutic agents, toxins, isotopes, and other agents used for treating conditions such as the killing of cancer cells. Chemotherapeutic agents may be any which are suitable for the purpose for which the antibody is being used.

The antibodies may be derivatized by known protecting/blocking groups to prevent proteolytic cleavage or enhance activity or stability.

Polynucleotide sequences that encode antibodies and their subdomains (*e.g.*, FRs and CDRs) are featured in the disclosure. Polynucleotides include, but are not limited to, RNA, DNA, cDNA, hybrids of RNA and DNA, and single, double, or triple stranded strands of RNA, DNA, or hybrids thereof. Polynucleotides may comprise a nucleic acid sequence encoding the heavy chain variable region and/or the light chain variable region of a 320-179 variant antibody as described or exemplified herein. Complements of the polynucleotide sequences are also within the scope of the disclosure.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3. A

polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 2 may comprise the nucleic acid sequence of SEQ ID NO: 50.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 4. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 4 may comprise the nucleic acid sequence of SEQ ID NO: 52.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 5 may comprise the nucleic acid sequence of SEQ ID NO: 53.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 6. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 6 may comprise the nucleic acid sequence of SEQ ID NO: 54.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 7. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 7 may comprise the nucleic acid sequence of SEQ ID NO: 55.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 8. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 8 may comprise the nucleic acid sequence of SEQ ID NO: 56.

A polynucleotide may comprise a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 10. A

polynucleotide encoding the amino acid sequence of SEQ ID NO: 10 may comprise the nucleic acid sequence of SEQ ID NO: 57.

In some aspects, a polynucleotide comprises a first nucleic acid sequence encoding an antibody heavy chain variable region and a second nucleic acid sequence encoding an antibody light chain variable region. A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 2. A

polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 2 may comprise the nucleic acid sequence of SEQ ID NO: 50.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 4 may comprise the nucleic acid sequence of SEQ ID NO: 52.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 6. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 6 may comprise the nucleic acid sequence of SEQ ID NO: 54.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 7. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 7 may comprise the nucleic acid sequence of SEQ ID NO: 55.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 8. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51

and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 8 may comprise the nucleic acid sequence of SEQ ID NO: 56.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 10. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 3 may comprise the nucleic acid sequence of SEQ ID NO: 51 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 10 may comprise the nucleic acid sequence of SEQ ID NO: 57.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 4. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 4 may comprise the nucleic acid sequence of SEQ ID NO: 52.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 5 may comprise the nucleic acid sequence of SEQ ID NO: 53.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 6. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 6 may comprise the nucleic acid sequence of SEQ ID NO: 54.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 7. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 7 may comprise the nucleic acid sequence of SEQ ID NO: 55.

A first nucleic acid sequence may encode an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 1 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 8. A polynucleotide encoding the amino acid sequence of SEQ ID NO: 1 may comprise the nucleic acid sequence of SEQ ID NO: 49 and a polynucleotide encoding the amino acid sequence of SEQ ID NO: 8 may comprise the nucleic acid sequence of SEQ ID NO: 56.

In some aspects, a polynucleotide comprises a first nucleic acid sequence encoding an antibody heavy chain variable region and a second nucleic acid sequence encoding a heavy chain constant region. In preferred aspects, a polynucleotide comprises a first nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 3 and a second nucleic acid sequence encoding an IgG1(Δ K) heavy chain constant region of SEQ ID NO: 43, for example, a polynucleotide comprising the nucleic acid sequence of SEQ ID NO: 58.

In some aspects, a polynucleotide comprises a first nucleic acid sequence encoding an antibody light chain variable region and a second nucleic acid sequence encoding a light chain constant region. In preferred aspects, a polynucleotide comprises a first nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO: 4 and a second nucleic acid sequence encoding a lambda light chain constant region of SEQ ID NO: 48, for example, a polynucleotide comprising the nucleic acid sequence of SEQ ID NO: 59.

Any of the polynucleotides described or exemplified herein may be comprised within a vector. Thus, vectors comprising polynucleotides are provided as part of the disclosure. The vectors may be expression vectors. Recombinant expression vectors containing a sequence encoding a polypeptide of interest are thus provided. The expression vector may contain one or more additional sequences, such as but not limited to regulatory sequences, a selection marker, a purification tag, or a polyadenylation signal. Such regulatory elements may include a transcriptional promoter, enhancers, mRNA ribosomal binding sites, or sequences that control the termination of transcription and translation.

Expression vectors, especially mammalian expression vectors, may include one or more nontranscribed elements, such as an origin of replication, a suitable promoter and enhancer linked to the gene to be expressed, other 5' or 3' flanking nontranscribed sequences, 5' or 3' nontranslated sequences (such as necessary ribosome binding sites), a

polyadenylation site, splice donor and acceptor sites, or transcriptional termination sequences. An origin of replication that confers the ability to replicate in a specific host may also be incorporated.

The vectors may be used to transform any of a wide array of host cells well known to those of skill in the art, and preferably host cells capable of expressing antibodies. Vectors include without limitation, plasmids, phagemids, cosmids, bacmids, bacterial artificial chromosomes (BACs), yeast artificial chromosomes (YACs), and baculovirus, as well as other bacterial, eukaryotic, yeast, and viral vectors. Suitable host cells include without limitation CHO cells, NS0 cells, HEK293 cells, or any eukaryotic stable cell line known or produced, and also include bacteria, yeast, and insect cells.

The antibodies may also be produced by hybridoma cells; methods to produce hybridomas being well known and established in the art.

The disclosure also provides compositions comprising the 320-179 variant antibodies. The compositions may comprise any of the antibodies described and/or exemplified herein and an acceptable carrier such as a pharmaceutically acceptable carrier. Suitable carriers include any media that does not interfere with the biological activity of the antibody and preferably is not toxic to a host to which it is administered. The compositions may be formulated for administration to a subject in any suitable dosage form.

The 320-179 variant antibodies may be used to treat a respiratory tract disease, a gastrointestinal disease, arthritis, or a skin disease in a subject. Thus, the disclosure features treatment methods. In general, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for a respiratory tract disease, gastrointestinal disease, arthritis, or a skin disease, such that the respiratory tract disease, gastrointestinal disease, arthritis, or skin disease is treated. The 320-179 variant antibody may comprise any antibody described or exemplified herein. Administering may comprise subcutaneously administering the antibody. Administering may comprise intravenously administering the antibody. The subject is preferably a human being. The subject may be a non-human primate such as a cynomolgus monkey, or may be a mammal such as a mouse, rat, guinea pig, cat, pig, rabbit, or dog.

In aspects where a respiratory tract disease is to be treated, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for a respiratory tract disease. The respiratory tract disease may comprise one or

more of asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pulmonary sarcoidosis, allergic rhinitis, or cystic fibrosis. Thus, for example, in some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for asthma, such that the asthma is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for COPD, such that the COPD is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for pulmonary fibrosis, such that the pulmonary fibrosis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for pulmonary sarcoidosis, such that the pulmonary sarcoidosis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for allergic rhinitis, such that the allergic rhinitis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for cystic fibrosis, such that the cystic fibrosis is treated in the subject.

In aspects where a gastrointestinal disease is to be treated, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for a gastrointestinal disease. The gastrointestinal disease may comprise one or more of inflammatory bowel disease (IBD), Crohn's disease, colitis, ulcerative colitis, irritable bowel syndrome (IBS), eosinophilic esophagitis, or a gastrointestinal disease or condition associated with cystic fibrosis. Thus, for example, in some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for IBD, such that the IBD is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for Crohn's disease, such that the Crohn's disease is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for colitis, such that the colitis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for ulcerative colitis, such that the ulcerative colitis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a

subject in need of treatment for IBS, such that the IBS is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for eosinophilic esophagitis, such that the eosinophilic esophagitis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for a gastrointestinal disease or condition associated with cystic fibrosis, such that the gastrointestinal disease or condition associated with cystic fibrosis is treated in the subject.

In aspects where arthritis is to be treated, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for arthritis. The arthritis may comprise rheumatoid arthritis. Thus, for example, in some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for rheumatoid arthritis, such that the rheumatoid arthritis is treated in the subject.

In aspects where a skin disease is to be treated, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for a skin disease. The skin disease may comprise one or more of atopic dermatitis, eczema, or scleroderma. Thus, for example, in some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for atopic dermatitis, such that the atopic dermatitis is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for eczema, such that the eczema is treated in the subject. In some aspects, the methods comprise administering a 320-179 variant antibody, or composition thereof, to a subject in need of treatment for scleroderma, such that the scleroderma is treated in the subject.

The 320-179 variant antibodies described or exemplified herein may be used in the preparation of a medicament for use in the treatment of a respiratory tract disease. The 320-179 variant antibodies described or exemplified herein may be used in the preparation of a medicament for use in the treatment of a gastrointestinal disease. The 320-179 variant antibodies described or exemplified herein may be used in the preparation of a medicament for use in the treatment of arthritis. The 320-179 variant antibodies described or exemplified herein may be used in the preparation of a medicament for use in the

treatment of a skin disease. The 320-179 variant antibodies described or exemplified herein may be used in the preparation of a medicament for use in the treatment of any one of asthma, COPD, pulmonary fibrosis, pulmonary sarcoidosis, allergic rhinitis, cystic fibrosis, inflammatory bowel disease, Crohn's disease, colitis, ulcerative colitis, irritable bowel syndrome, eosinophilic esophagitis, a gastrointestinal disease or condition associated with cystic fibrosis, arthritis, rheumatoid arthritis, atopic dermatitis, eczema, or scleroderma.

The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of a respiratory tract disease. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of a gastrointestinal disease. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of asthma. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of a skin disease. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of COPD. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of pulmonary fibrosis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of pulmonary sarcoidosis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of allergic rhinitis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of cystic fibrosis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of inflammatory bowel disease. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of Crohn's disease. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of colitis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of ulcerative colitis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of eosinophilic esophagitis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of a gastrointestinal disease or condition associated with cystic fibrosis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of irritable bowel syndrome. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of rheumatoid arthritis. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of atopic dermatitis. The 320-179 variant antibodies described or exemplified

herein may be for use in the treatment of eczema. The 320-179 variant antibodies described or exemplified herein may be for use in the treatment of scleroderma.

Also provided is an *in vitro* method for detecting TL1A in a tissue sample isolated from a subject, comprising contacting the antibody according to any one of claims 1-19 with a tissue sample isolated from a subject to form an antibody-TL1A complex, and detecting the complex in the tissue sample.

A 320-179 variant antibody may be used to detect TL1A-positive cells, for example, in a tissue sample obtained from a subject. The antibodies may be used to detect TL1A-positive peripheral blood mononuclear cells (PBMCs), for example, PBMCs obtained from a subject. The antibodies may be used to detect TL1A in the blood serum. Such methods may be carried out *in vivo*, *ex vivo*, *in vitro*, or *in situ*. In general, the methods comprise contacting any of the 320-179 variant antibodies described or exemplified herein with a tissue or cells, *e.g.*, PBMCs, isolated from a subject to form an antibody-TL1A complex, and detecting the complex in the tissue or on the cells. The antibody may be labelled with a detectable label. The antibody may be detected with a secondary antibody that is labelled with a detectable label. The tissue may comprise or may be a biological fluid such as blood or blood serum. The tissue may comprise or may be respiratory tract tissue, such as lung tissue, sputum, bronchoalveolar lavage fluid, gastrointestinal tissue, or gastrointestinal lavage fluid. The tissue may comprise or may be skin or dermal tissue. The tissue may comprise or may be tissue of any joint in the body. The method may further comprise isolating the tissue from the subject. Such methods may be quantitative, for example, by quantifying the level of TL1A in the tissue, by quantifying the level of TL1A-positive cells, or by quantifying the level of TL1A on cells, or by quantifying the level of TL1A in the serum.

The disclosure also features kits comprising any of the 320-179 variant antibodies described and exemplified herein. The kits may be used to supply antibodies and other agents for use in diagnostic, basic research, or therapeutic methods, among others. In some aspects, the kits comprise any one or more of the 320-179 variant antibodies described or exemplified herein and instructions for using the one or more antibodies in a method for treating a respiratory tract disease, in a method for treating a gastrointestinal disease, or in a method for treating arthritis.

The following examples are provided to describe the disclosure in greater detail. They are intended to illustrate, not to limit, the disclosure.

Example 1

Materials and Methods

Amino acid positions in these examples are numbered according to the Kabat numbering system. CDRs are defined according to the AbM method of CDR definition system throughout this document.

1.1. Generation of variant bundles. The heavy- and light chain variable region amino acid sequences of antibody 320-179 (SEQ ID NOs: 1 and 2 respectively) were used as templates for the design of point variants. 320-179 has been previously described in U.S. Publ. No. 2014/0255302 (VH is SEQ ID NO: 186 and VL is SEQ ID NO: 199 in that publication) as 320-179 (also described as C320-179). This antibody had favorable biophysical properties, was a potent inhibitor of TL1A and had a low predicted immunogenicity profile.

Antibody variants of 320-179 were made by substituting one of a group of nine representative amino acids – A, S, Q, D, H, K, L, W, Y – one at a time at one of each CDR amino acid position (as defined by AbM nomenclature) in the light chain CDR1 (CDR-L1), the light chain CDR3 (CDR-L3), the heavy chain CDR1 (CDR-H1) and the heavy chain CDR2 (CDR-H2). Antibody variants, incorporating A, S, Q, D, H, K, L, W, Y, were also made at position 59 and 60 in the variable heavy chain and at position 79 in the variable light chain. A complete list of all single substituted antibody variants generated is shown in Figures 1 (variable heavy chain) and 2 (variable light chain), respectively.

1.2. Construction of Vectors Expressing Antibodies. Variable region variants were generated by back-translation of amino acid sequences into DNA sequences which were subsequently synthesized *de novo* by assembly of synthetic oligonucleotides. V_H variants were subcloned into a mammalian expression vector containing a human constant region to produce full-length antibody heavy chains (human IgG1 heavy chain C_H1, hinge, C_H2 and C_H3 domains) (*e.g.*, UniProt No. P01857). Similarly, V_L variants were subcloned into a mammalian expression vector containing a human lambda light chain constant region to produce full-length antibody lambda chains (SwissProt No. P0CG05.1). In some instances, the full-length heavy chain and, separately, light chain, was back-translated into DNA sequences and subsequently synthesized *de novo* by assembly of synthetic oligonucleotides.

1.3. Expression of antibody variants. Antibodies were produced by co-transfecting antibody heavy- and light chains into EXP1293[®] cells (Life Technologies, Carlsbad, CA). The day before transfection, the number of cells needed for the experiment was determined.

For each 20 mL transfection, 3.6×10^7 cells were required in 20 mL of EXPI293[®] Expression Medium. On the day prior to transfection, cells were seeded at a density of 0.9×10^6 viable cells/mL and incubated overnight at 37° C in a humidified atmosphere of 8% CO₂ in air on an orbital shaker rotating at 200 rpm. On the day of transfection, the cell number and viability were determined using an automated cell counter. Only cultures with >98% viable cells were used. For each 20 mL transfection, lipid-DNA complexes were prepared by diluting 10 µg of heavy chain DNA and 10 µg of light chain DNA in OPTI-MEM[®] (Life Technologies, Carlsbad, CA) I Reduced Serum Medium (Cat. no. 31985-062) to a total volume of 1.0 mL. 54 µL of EXPIFECTAMINE[®] 293 Reagent (Life Technologies, Carlsbad, CA) was diluted in OPTI-MEM[®] I medium to a total volume of 1.0 mL. Both vials were mixed gently and incubated for 5 minutes at room temperature. Following incubation, the diluted DNA was mixed with the diluted EXPIFECTAMINE[®] 293 Reagent and the DNA-EXPIFECTAMINE[®] 293 Reagent mixture and incubated a further 20 minutes at room temperature to allow the formation of DNA-EXPIFECTAMINE[®] 293 Reagent complexes. Following incubation, 2 mL of DNA-EXPIFECTAMINE[®] 293 Reagent complex was added to each 50mL bioreactor tube (TPP Techno Plastic Products AG). To the negative control tube, 2 mL of OPTI-MEM[®] (Life Technologies, Carlsbad, CA) I medium was added instead of DNA-EXPIFECTAMINE[®] 293 Reagent complex. The cells were incubated in a 37° C incubator with a humidified atmosphere of 8% CO₂ in air on an orbital shaker rotating at 200 rpm. Approximately 16–18 hours post-transfection, 100 µL of EXPIFECTAMINE[®] 293 Transfection Enhancer 1 and 1.0 mL of EXPIFECTAMINE[®] 293 Transfection Enhancer 2 were added to each bioreactor. Antibodies were harvested at approximately 72 hours post-transfection.

1.4. Purification of antibody variants. Each antibody variant was expressed in EXPI293[®] cells in 20 mL of cell culture. Cultures were spun down in 50 mL falcon tubes at 3000 x g for 20 minutes, and supernatants were filtered using a 0.22 µm filter (Corning). Supernatants were purified using a Gilson ASPEC GX274 robot. Briefly, SPE cartridges (Agilent, 12131014) packed with 1.2 mL MABSELECT SURE[®] protein A (GE Healthcare Bio-Sciences AB Uppsala, Sweden) resin were pre-equilibrated with 3 column volumes of 1X PBS. 18 mL of supernatant was run over the columns followed by a 4 ml 1X PBS wash. Each column was pre-eluted with 0.9 mL of 0.1 M citric acid, pH 2.9. Purified antibodies were eluted with 2 mL 0.1 M citric acid, pH 2.9. Antibodies were desalted into Sørensen's PBS

(59.5 mM KH₂PO₄, 7.3 mM Na₂HPO₄·2H₂O, 145.4 mM NaCl (pH ~5.8)) using PD-10 columns (GE Healthcare).

1.5. Antibody expression and antigen binding as determined by SPR. Using a CM5 sensor chip (GE Healthcare) Protein A (Pierce) was coupled to the chip surface using an amine coupling kit (GE Healthcare). Protein A was coupled on flow cell 1 and 2 (or alternatively 3 and 4) using a BIACORE® T200. Supernatants from EXPI-293® cells containing antibody or alternatively purified antibodies (as described in 1.4) were passed over the surface of flow cell 2, while buffer (HBS-EP) was passed over flow cell 1. The amount of supernatant or purified protein (as well as the concentration) injected during the capture stage varied between runs and is specified in the header of the Tables 3-11. At the end of injection of the supernatant or purified antibody the change in response units was measured. This value was reported as Capture Level in Tables 3-11. To determine if the antibody bound TL1A, the TL1A was then passed over flow cells 1 and 2 and the response units measured prior to the end of the injection of TL1A (the association phase). This value is labeled as TL1A Binding Level (Early) in Tables 3-11. The response units were measured prior to the end of the dissociation phase. This value is labeled as TL1A Binding Level (Late) in Tables 3-11 and is a measure of the amount of antibody that has been lost from the surface of the chip as a result of dissociation of the TL1A – antibody complex. The sensorgrams were double referenced (flow cell 2 is subtracted from flow cell 1 and a buffer blank). As there were a large number of antibody variants to screen, these were screened across different runs (Tables 3-11). In each case (except Run 3) the parent antibody, 320-179 was included in the run, for comparison purposes. A summary of the conditions used in each run is below:

Table 1.

Run #	Super-natant	Protein	Approx-imate capture level (RU)	Conc. TL1A sample (ug/mL)	TL1A Binding Level (Early) timepoint	TL1A Binding Level (Late) timepoint	Notes
1		x	400	10	59	590	Antibody diluted to 2 ug/mL, variable capture time
2	x		1000	10	44	220	Supernatant diluted into running buffer, variable capture

							times
2		x	400	10	44	590	Antibody diluted 2 ug/mL, variable capture time
3	x		variable	10	59	590	Supernatant diluted into running buffer, 60 s capture
4		x	500	5	44	220	Antibody diluted to 2 ug/mL into running buffer
5	x		100	5	44	220	Supernatant diluted into running buffer,
6		x	variable	5	44	170	Antibody diluted to 2 ug/mL into running buffer and captured for 45 s
7*		x	400	5	44	220	Antibody diluted to approx. 2 ug/mL
8		x	400	5	44	590	Antibody diluted to 2 ug/mL, variable capture time
9		x	400	5	44	590	Antibody diluted to 2 ug/mL, variable capture time

* This run was performed on a Biacore® A100

The binding of anti-TL1A to different species TL1A was also determined using SPR. The anti-TL1A antibody was captured on the surface of a Protein A. TL1A from either human, rat, mouse, rabbit, guinea pig, pig, dog, cat or cynomolgus monkey were flowed over the surface and the response units measured.

1.6. Production of TL1A. Human TL1A was produced in the mammalian EXP293® expression system, using a DNA expression construct coding for the extracellular domain (ECD) of human TL1A with an N-terminally located HIS and FLAG tag. Other species forms of TL1A were generated based on sequence listing on publically listed databases. These are summarized below:

Table 2.

Species TL1A	Public Database Reference	SEQ ID NO:
Human	UniProt: O95150	31
Cynomolgus Monkey	SEQ ID NO: 125 from US Publ. No. 2014/0255302	34
Mouse	UniProt: Q5UBV8	35

Rat	UniProt: Q8K3Y7	36
Guinea Pig	UniProt: HOVFN8	37
Cat	NCBI: XP_003995828.1	38
Pig	UniProt: I3LL00	39
Rabbit	UniProt: G1T1T1	40
Dog	UniProt: J9P221	41

Culture supernatant containing the secreted TL1A protein was harvested by centrifugation at 2000 x g for 10 mins to remove the cells. The TL1A protein was purified from the supernatant using a HISTRAP® HP column (GE Healthcare). The eluted protein was buffer-exchanged into PBS using a HILOAD® 16/60 Superdex 200 prep grade column (GE Healthcare) and ~70 kDa fraction was separated by gel filtration on a HILOAD® 26/60 SUPERDEX® 200 prep grade column (GE Healthcare).

1.7. TF-1 Cell Line Potency Assay. To determine which anti-TL1A antibodies functionally neutralize the biological activity of TL1A, antibodies were tested for their ability to neutralize TL1A-induced apoptosis in a TF-1 cell line. The TF-1 human erythroleukemic cell line (ATCC: CRL-2003) was maintained in culture under standard conditions. TF-1 cells (7.5×10^4 /well) were incubated in black-sided 96-well plates (Greiner) with human TL1A 100 ng/ml and cycloheximide 10 µg/ml to induce apoptosis. Test antibodies at a concentration of 10 µg/mL (66.7 nM) or less were added to the plates and incubated for 4 to 5 hours. Induction of apoptosis was then assessed using the Homogeneous Caspases Kit (Roche) according to manufacturer's instructions.

Data were normalized by expression as a percentage of maximum apoptosis (apoptosis levels achieved by human TL1A plus cycloheximide in the absence of anti-TL1A antibody).

1.8. Receptor Selectivity of Lead Antibodies. TL1A binds both to its cognate signaling receptor, DR3, and to a decoy receptor, DcR3, which also serves as a decoy receptor for TNF family members Fas-L and LIGHT. Antibodies were assessed for their ability to inhibit binding of TL1A to its receptors in a competition ELISA. DR3/Fc Chimera (R&D Systems) or DcR3/Fc Chimera (R&D Systems) was coated onto a 96-well plate (Maxisorp, Nunc) at a concentration of 2µg/ml. Serially diluted test antibodies were pre-incubated with single-site biotinylated human TL1A 1µg/ml for 30 minutes then added to

the DR3/Fc or DcR3/Fc coated wells. Bound TL1A was detected using streptavidin-horseradish peroxidase 1:2000 (BD Pharmingen). Data were normalized by expression as a percentage of maximum binding of TL1A to receptor in the absence of anti-TL1A antibody.

1.9. Kinetic Exclusion Assay. This assay measures the free concentration of one of the binding partners without perturbing the equilibrium. Solutions can be prepared off-line, using unmodified proteins in solution, and affinity measurements can be read days after mixing to ensure that equilibrium has been reached. In a kinetic exclusion assay, one interactant (termed the constant binding partner, or CBP) is held at a constant concentration, while the other (termed the titrant) is serially diluted. Kinetic exclusion assays may be used to determine the dissociation constant (K_D) and affinity of an antibody-antigen interaction. In a typical kinetic exclusion assay, the titrant is immobilized to beads (*e.g.*, Sepharose or PMMA beads) and is used to capture the CBP free in solution. A secondary labeled probe is then used to quantify the amount of captured CBP. The kinetic exclusion assay is reviewed in Darling, RK *et al.* (2004) *ASSAY and Drug Development Technol.* 2(6):647-57.

The components were combined and allowed to reach equilibrium. The kinetic exclusion assay was then used to measure the free fraction of the CBP. Equilibrium curves with multiple CBP concentrations were analyzed using the n-curve analysis tool within the KinExA® Pro software (Version 4.1.11, Savidyne) to obtain robust K_D determinations. The interaction of 320-587 for human TL1A was examined using two orientations: (1) CBP is 320-587, titrant is TL1A, and (2) CBP is TL1A, titrant is 320-587.

Example 2

Experimental Results

2.1. Selecting TL1A-binding variants with an equivalent or improved off-rate relative to C320-179. Variants of antibody 320-179 were constructed and expressed as described above. EXP1293® (Life Technologies Corp.) supernatants of each variant were assessed by BIACORE® (GE Healthcare) and the data obtained compared with that of the parental antibody 320-179. In some experiment the antibodies were purified using Protein A chromatography (See 1.4) and purified antibodies were used in BIACORE® (GE Healthcare) experiments. Tables 3-11 show the expression level of each variant, along with its binding

to TL1A at an early and late time point. In later runs (Table 10 and 11) antibody variants containing more than one amino acid substitution were tested.

Table 3. SPR experiment – Run 1 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-179	None	None	410	140	117
320-184*	None	L79A	414	141	118
320-185*	None	L79S	401	137	114
320-186*	None	L79Q	398	136	113
320-187*	None	L79D	388	134	112
320-188*	None	L79H	397	136	113
320-189*	None	L79K	393	130	107
320-190*	None	L79W	395	136	113
320-191*	None	L79Y	408	140	117

Table 4. SPR experiment – Run 2 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant			Purified Antibody		
320-179	None	None	1133	287	261	410	140	117
320-192	None	T24A	960	238	218	-	-	-
320-193	None	T24S	990	249	227	409	103	91
320-194	None	T24Q	974	247	226	398	76	64
320-195	None	T24D	992	249	227	-	-	-
320-196	None	T24H	995	250	228	-	-	-
320-197	None	T24K	1017	255	232	401	105	94
320-198*	None	T24L	1023	262	241	-	-	-
320-199	None	T24W	1050	251	233	404	97	85
320-200	None	T24Y	1027	251	231			
320-201*	None	S25A	990	274	252	393	73	57
320-202*	None	S25Q	1034	234	214	-	-	-
320-203	None	S25D	977	61	24	407	65	35
320-204	None	S25H	1003	193	155	-	-	-
320-205*	None	S25K	1025	290	271	401	70	51

Antibody	VH Substituti on relative to 320- 179	VL Substituti on relative to 320- 179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant			Purified Antibody		
320-206	None	S25L	1000	257	235	-	-	-
320-207*	None	S25W	1022	268	243	-	-	-
320-208	None	S25Y	1034	222	199	-	-	-
320-209*	None	S26A	1007	222	200	-	-	-
320-210	None	S26Q	1033	225	202	-	-	-
320-211*	None	S26D	1025	206	164	392	80	64
320-212	None	S26H	1013	226	205	-	-	-
320-213*	None	S26K	1052	218	194	422	79	65
320-214	None	S26L	1038	221	196	-	-	-
320-215	None	S26W	1021	220	199	-	-	-
320-216	None	S26Y	1010	171	147	-	-	-
320-217	None	S27A	1076	258	235	-	-	-
320-218	None	S27Q	1081	239	218	412	92	80
320-219*	None	S27D	1061	243	220	-	-	-
320-220	None	S27H	1049	253	230	-	-	-
320-221	None	S27K	1063	225	207	413	99	89
320-222	None	S27L	1037	156	96	-	-	-
320-223	None	S27W	1061	143	66	-	-	-
320-224	None	S27Y	1055	198	153	-	-	-
320-225	None	S27aA	1066	267	243	-	-	-
320-226*	None	S27aQ	1035	250	228	-	-	-
320-227	None	S27aD	1022	242	218	-	-	-
320-228	None	S27aH	1072	259	235	-	-	-
320-229*	None	S27aK	1057	268	251	-	-	-
320-230	None	S27aL	1087	245	223	-	-	-
320-231	None	S27aW	1078	271	243	-	-	-
320-232	None	S27aY	1051	261	235	-	-	-
320-233	None	D27bA	1118	255	235	409	48	16
320-234	None	D27bS	1089	262	239	-	-	-
320-235	None	D27bQ	1110	256	236	-	-	-
320-236	None	D27bH	1085	254	232	415	5	6
320-237	None	D27bK	1073	240	221	398	10	8
320-238	None	D27bL	1106	221	191	-	-	-
320-239	None	D27bW	1079	212	163	-	-	-
320-240	None	D27bY	1089	230	196	-	-	-
320-241*	None	I27cA	1092	179	122	-	-	-
320-242	None	I27cS	1076	124	49	-	-	-
320-243	None	I27cQ	1065	71	26	-	-	-
320-244*	None	I27cD	1083	21	20	-	-	-
320-245*	None	I27cH	1084	59	26	-	-	-
320-246	None	I27cK	1089	32	23	-	-	-

Antibody	VH Substitution relative to 320- 179	VL Substitution relative to 320- 179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant			Purified Antibody		
320-247	None	I27cL	1078	205	162	-	-	-
320-248	None	I27cW	1110	96	30	-	-	-
320-249	None	I27cY	1096	77	28	-	-	-
320-250	None	G28A	1104	180	115	-	-	-
320-251	None	G28S	1085	134	50	-	-	-

Table 5. SPR experiment – Run 3 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant		
320-252	None	G28Q	996	20	9
320-253	None	G28D	1073	6	6
320-254	None	G28H	1021	17	8
320-255	None	G28K	842	24	8
320-256	None	G28L	1055	30	10
320-257	None	G28W	981	83	18
320-258	None	G28Y	823	9	6
320-259	None	A29S	824	194	179
320-260	None	A29Q	836	182	165
320-261	None	A29D	956	86	29
320-262	None	A29H	891	209	190
320-263*	None	A29K	848	121	123
320-264	None	A29L	831	199	184
320-265	None	A29W	1057	168	69
320-266	None	A29Y	934	218	192
320-267*	None	G30A	1148	299	297
320-268	None	G30S	392	28	7
320-269	None	G30Q	764	126	93
320-270	None	G30D	511	9	5
320-271	None	G30H	1067	106	30
320-272	None	G30K	935	5	5
320-273	None	G30L	710	4	4
320-274	None	G30W	796	12	7
320-275	None	G30Y	751	44	10

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant		
320-276	None	L31A	1273	244	215
320-277*	None	L31S	1741	387	361
320-278*	None	L31Q	1696	389	374
320-279	None	L31D	561	144	128
320-280*	None	L31H	881	228	211
320-281	None	L31K	321	22	6
320-282	None	L31W	811	75	16
320-283	None	L31Y	317	2	3
320-284	None	G32A	374	1	2
320-285	None	G32S	400	1	2
320-286	None	G32Q	576	1	4
320-287	None	G32D	339	0	2
320-288	None	G32H	422	1	3
320-289	None	G32K	463	1	3
320-290	None	G32L	361	1	2
320-291	None	G32W	414	2	3
320-292	None	G32Y	423	111	94
320-293	None	V33A	421	104	86
320-294	None	V33S	419	79	61
320-295	None	V33Q	414	109	94
320-296	None	V33D	428	118	104
320-297*	None	V33H	420	95	77
320-298	None	V33K	416	114	100
320-299	None	V33L	420	51	13
320-300	None	H34W	417	111	95
320-301	None	H34Y	456	108	96
320-302*	None	H34A	423	99	74
320-303	None	H34S	408	71	32
320-304	None	H34Q	401	103	82
320-305	None	H34D	424	34	10
320-306	None	H34K	452	147	133
320-307*	None	H34L	873	216	200
320-308	None	H34W	458	106	73
320-309	None	H34Y	255	47	40
320-310	None	Q89A	348	70	62
320-311	None	Q89S	0	0	0

Table 6. SPR experiment – Run 4 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-179	None	None	616	177	163
320-312	None	Q89D	529	10	10
320-313*	None	Q89H	502	141	132
320-314*	None	Q89K	598	165	158
320-315	None	Q89L	515	85	82
320-316	None	Q89W	535	65	62
320-317	None	Q89Y	570	86	83
320-318*	None	S90A	578	160	149
320-319	None	S90Q	523	18	14
320-320	None	S90D	534	31	17
320-321	None	S90H	491	16	13
320-322	None	S90K	450	17	14
320-323	None	S90W	490	14	13
320-324	None	S90Y	528	13	12
320-325	None	Y91A	491	95	83
320-326*	None	Y91S	550	126	120
320-327	None	Y91Q	493	130	119
320-328*	None	Y91H	542	155	146
320-329	None	Y91K	600	9	11
320-330	None	Y91L	600	139	119
320-331*	None	Y91W	615	173	176
320-332	None	D92A	531	66	44
320-333	None	D92S	559	95	67
320-334	None	D92Q	543	15	14
320-335	None	D92H	581	15	14
320-336	None	D92K	484	11	11
320-337	None	D92L	475	21	15
320-338	None	D92W	548	9	11
320-339	None	D92Y	509	10	11
320-340	None	G93A	548	145	132
320-341	None	G93S	560	149	135
320-342	None	G93Q	560	152	139
320-343	None	G93D	545	121	90
320-344	None	G93H	529	117	87
320-345*	None	G93K	637	163	154
320-346	None	G93L	526	126	107

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-347	None	G93W	560	149	130
320-348	None	G93Y	541	144	127
320-349	None	T94A	556	112	88
320-350	None	T94S	502	130	118
320-351	None	T94Q	553	112	83
320-352	None	T94D	568	101	63
320-353	None	T94H	558	97	73
320-354	None	T94K	536	53	30
320-355	None	T94L	526	102	76
320-356	None	T94W	486	109	86
320-357	None	T94Y	563	119	91
320-358	None	L95A	501	82	50
320-359	None	L95S	503	57	27
320-360	None	L95Q	554	86	53
320-361*	None	L95D	477	12	11
320-362	None	L95H	522	8	9
320-363	None	L95Y	566	17	16
320-364	None	S95aA	516	124	109
320-365	None	S95aQ	536	141	128
320-366	None	S95aD	487	62	31
320-367	None	S95aH	595	119	116
320-368	None	S95aK	602	50	26
320-369	None	S95aL	503	89	60
320-370	None	S95aW	570	66	39
320-371	None	S95aY	576	92	70

Table 7. SPR experiment – Run 5 – Anti-TL1A antibodies binding to TL1A.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant		
320-179	None	None	83	11	10
320-372	None	A96S	106	1	0
320-373	None	A96Q	99	-1	-1
320-374	None	A96D	98	1	0
320-375	None	A96H	108	-2	-1
320-376	None	A96K	98	3	1
320-377	None	A96L	101	-1	-1

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant		
320-378	None	A96W	105	-1	-1
320-379	None	A96Y	105	3	1
320-380	None	L97A	104	1	1
320-381	None	L97S	97	3	1
320-382	None	L97Q	106	0	0
320-383	None	L97D	102	3	1
320-384	None	L97H	98	3	2
320-385	None	L97K	108	1	1
320-386	None	L97W	104	1	0
320-387	None	L97Y	97	11	10
320-388	G26A	None	110	14	13
320-389	G26S	None	105	12	11
320-390	G26Q	None	100	12	11
320-391	G26D	None	106	14	13
320-392	G26H	None	109	12	11
320-393	G26K	None	100	12	11
320-394	G26L	None	106	13	12
320-395	G26W	None	104	13	12
320-396	G26Y	None	104	12	11
320-397	Y27A	None	109	12	12
320-398	Y27S	None	110	12	11
320-399	Y27Q	None	105	10	10
320-400	Y27D	None	106	11	11
320-401	Y27H	None	100	11	10
320-402	Y27L	None	98	11	10
320-403	Y27W	None	84	11	10
320-404	T28A	None	84	11	10
320-405	T28S	None	79	10	9
320-406	T28Q	None	82	8	7
320-407	T28D	None	88	12	11
320-408	T28H	None	81	13	12
320-409	T28K	None	83	10	10
320-410	T28L	None	86	11	10
320-411	T28W	None	82	10	9
320-412	T28Y	None	89	10	9
320-413	F29A	None	89	9	8
320-414	F29S	None	78	7	7
320-415	F29Q	None	85	5	4
320-416	F29D	None	81	9	8

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Supernatant		
320-417	F29H	None	85	9	8
320-418	F29K	None	85	10	9
320-419	F29L	None	83	11	9
320-420	F29W	None	85	11	10
320-421	F28Y	None	81	9	8
320-422	T30A	None	80	10	9
320-423	T30S	None	86	10	10
320-424	T30Q	None	86	11	10
320-425	T30D	None	89	14	12
320-426	T30H	None	84	10	9
320-427	T30K	None	88	11	10
320-428	T30L	None	88	11	10
320-429	T30W	None	90	12	11
320-430	T30Y	None	85	6	6
320-431	S31A	None	85	6	6

Table 8. SPR experiment – Run 6 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-179	None	None	449	111	102
320-432	S31Q	None	466	116	106
320-433	S31D	None	412	90	83
320-434	S31K	None	473	125	113
320-435	S31L	None	384	92	83
320-436	S31W	None	525	129	118
320-437	S31Y	None	501	119	109
320-438	Y32A	None	468	126	116
320-439	Y32S	None	464	119	108
320-440	Y32Q	None	408	108	97
320-441	Y32D	None	388	80	67
320-442	Y32H	None	490	124	113
320-443*	Y32K	None	438	114	103
320-444	Y32L	None	458	107	95
320-445*	Y32W	None	442	116	106
320-446	D33A	None	469	18	8

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-447	D33S	None	503	37	13
320-448	D33Q	None	482	7	6
320-449	D33H	None	483	76	59
320-450	D33K	None	536	1	3
320-451	D33L	None	497	19	8
320-452	D33W	None	445	84	78
320-453	D33Y	None	449	111	104
320-454	I34A	None	189	43	37
320-455	I34S	None	144	27	23
320-456	I34Q	None	214	52	46
320-457	I34D	None	55	6	4
320-458	I34H	None	239	59	53
320-459	I34K	None	93	20	17
320-460	I34L	None	441	114	105
320-461	I34W	None	465	87	82
320-462	I34Y	None	373	58	52
320-463*	N35A	None	462	102	101
320-464*	N35S	None	600	130	124
320-465	N35Q	None	476	92	78
320-466	N35D	None	360	93	86
320-467	N35H	None	350	44	24
320-468	N35K	None	200	2	2
320-469	N35L	None	315	69	61
320-470	N35W	None	329	2	3
320-471	N35Y	None	312	3	4
320-472	None	S90L	467	23	10
320-473	None	Y91D	453	69	55
320-474	None	L95K	596	2	4
320-475	None	L95W	727	8	8
320-476	Y27K	None	560	128	118
320-477*	S31H	None	576	148	136
320-478	A60L	None	379	85	77
320-479	A60W	None	277	61	54
320-480	A60Y	None	319	79	73
320-483	W50A	None	492	4	6
320-484	W50S	None	555	3	6
320-485	W50Q	None	460	3	5
320-486	W50D	None	178	1	2

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
320-487	W50H	None	237	2	3
320-488	W50K	None	293	1	2
320-489	W50L	None	337	4	5
320-490	W50Y	None	393	14	8
320-491	L51S	None	356	85	76

Table 9. SPR experiment – Run 7 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
320-179	None	None	301	61	56
320-492	L51Q	None	439	89	82
320-493	L51D	None	242	48	46
320-494	L51H	None	811	150	138
320-495	L51K	None	466	84	77
320-496	L51W	None	581	93	87
320-497	N52A	None	727	135	125
320-498	N52S	None	485	90	82
320-499	N52Q	None	551	122	113
320-500	N52D	None	472	69	53
320-501	N52H	None	533	118	108
320-502	N52K	None	659	88	59
320-503	N52W	None	484	41	6
320-504	N52Y	None	500	88	65
320-505	P52aA	None	570	118	110
320-506	P52aS	None	444	97	89
320-507	P52aQ	None	181	27	24
320-508	P52aD	None	203	19	12
320-509	P52aH	None	290	52	47
320-510	P52aK	None	289	44	33
320-511	P52aL	None	581	106	98
320-512	P52aW	None	746	126	118
320-513	P52aY	None	585	99	90
320-514	N53A	None	516	96	88
320-515	N53S	None	375	73	67
320-516	N53Q	None	461	92	86

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-517	N53D	None	493	55	50
320-518	N53H	None	882	169	153
320-519	N53K	None	993	217	196
320-520	N53L	None	1016	174	162
320-521	N53W	None	830	166	152
320-522	N53Y	None	693	141	129
320-523	S54A	None	476	88	82
320-524	S54Q	None	292	55	49
320-525	S54D	None	437	33	17
320-526	S54H	None	672	134	124
320-527	S54K	None	578	146	136
320-528	S54L	None	829	121	108
320-529	S54W	None	605	94	83
320-530	S54Y	None	425	77	67
320-531	G55A	None	331	66	61
320-532	G55S	None	648	10	7
320-533	G55Q	None	441	93	86
320-534	G55D	None	647	109	102
320-535	G55H	None	637	126	115
320-536	G55K	None	553	115	105
320-537	G55L	None	717	133	123
320-538	G55W	None	318	54	49
320-539	N56A	None	859	172	159
320-540	N56S	None	500	100	92
320-541	N56Q	None	504	94	84
320-542	N56D	None	839	97	86
320-543	N56H	None	597	138	126
320-544	N56K	None	690	120	112
320-545	N56L	None	518	109	100
320-546	N56W	None	341	67	61
320-547*	N56Y	None	318	77	75
320-548	T57A	None	335	74	68
320-549	T57S	None	269	50	45
320-550	T57Q	None	635	112	103
320-551	T57D	None	280	44	36
320-552	T57H	None	595	104	97
320-553	T57K	None	494	84	78
320-554	T57L	None	506	66	51
320-555	T57W	None	674	62	30

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-556	T57Y	None	634	100	90
320-557	G58A	None	378	26	6
320-558	G58S	None	463	3	2
320-559	G58Q	None	535	9	5
320-560	G58D	None	907	36	9
320-561	G58H	None	539	14	6
320-562	G58K	None	326	2	1
320-563	G58L	None	258	2	2
320-564	G58W	None	345	72	67
320-565	G58Y	None	545	43	12
320-566	Y59A	None	720	120	110
320-567	Y59S	None	590	96	86
320-568	Y59Q	None	688	115	107
320-569	Y59D	None	408	79	73
320-570	Y59H	None	435	79	72
320-571	Y59K	None	394	78	72
320-572	A60S	None	459	98	90
320-573	A60Q	None	338	67	62
320-574	A60D	None	693	140	130
320-575	A60H	None	581	121	110
320-576	A60K	None	479	90	83
320-577	L51A	None	479	98	90
320-578	L51Y	None	415	83	77
320-579	N52L	None	214	46	41
320-580	G55Y	None	261	51	47
320-581	Y59L	None	337	70	65
320-582	Y59W	None	453	67	52

Table 10. SPR experiment – Run 8 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-179	None	None	402	98	86
320-583*	None	G30A, Y91W	404	108	103
320-584*	None	L31S, Y91W	399	103	98
320-585*	None	L31Q, Y91W	406	116	109

320-586*	None	H34L, Y91W	405	108	103
320-587*	N56Y	Y91W	402	123	122
320-588*	N56Y	G30A	409	128	123
320-589*	N56Y	L31S	399	120	109
320-590*	N56Y	L31Q	405	130	121
320-591*	N56Y	H34L	399	132	124
320-592*	N56Y	G30A, Y91W	408	128	129
320-593*	N56Y	L31S, Y91W	405	126	124
320-594*	N56Y	L31Q, Y91W	407	134	132
320-595*	N56Y	H34L, Y91W	403	129	128

Table 11. SPR experiment – Run 9 – Anti-TL1A antibodies binding to TL1A. * indicates antibodies that were selected for potency assay testing.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Capture Level	TL1A Binding Level (Early)	TL1A Binding Level (Late)
			Purified Antibody		
320-179	None	None	402	108	98
320-596	None	Y91F	405	95	85
320-597	None	L31Q, Y91F	401	115	105
320-598	None	H34L, Y91F	403	112	101
320-599	None	L31S, Y91F	411	113	103
320-600	None	G30A, Y91F	399	111	104
320-601*	N56Y	Y91F	409	121	120
320-602	N56Y	L31Q, Y91F	399	131	125
320-603	N56Y	H34L, Y91F	394	126	118
320-605	N56Y	G30A, Y91F	399	125	120
320-611*	N56Y	Y91W, G93K	397	125	127
320-612	None	Y91W, G93Y	400	126	120
320-613*	N56Y	Y91W, G93Y	408	135	131
320-614	N56Y	G93K	401	122	111
320-615	N56Y	G93Y	393	113	108
320-616	N56Y	G93A	396	120	112

Antibodies that had capture levels similar or better than 320-179 as well as a TL1A Binding Level (Early) and TL1A Binding Level (Late) values that were in a similar range were taken forward into potency assays. These variants are indicated by shading in Tables 3-11. A comparison of the off-rate as measured by SPR for several of the antibodies is shown in Figure 5. Several of the antibodies dissociated at a slower rate than that of the parental antibody 320-179.

2.2 Anti-TL1A antibodies with improved potency in cell based assay. To assess if improved off-rate correlated with an enhanced potency purified antibody, variants were run in the TL1A induced caspase activity assay in TF-1 cells. Potent antibodies act by binding to TL1A and inhibiting TL1A activation of the DR3 receptor. This receptor triggers an apoptosis pathway in which caspases are activated and can be detected using commercial reagents. In each experiment the antibody variant was compared to 320-179 for fold improvement in potency. The results are shown in Table 12.

Table 12. TL1A induced caspase potency assay in TF-1 cells: Inhibition by anti-TL1A antibodies.

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Antibody IC ₅₀ (µg/mL)	320-179 IC ₅₀ (µg/mL)	Fold improvement
320-184	None	L79A	0.010	0.030	3
320-185	None	L79S	0.020	0.030	2
320-186	None	L79Q	0.030	0.030	1
320-187	None	L79D	0.020	0.040	2
320-188	None	L79H	0.010	0.040	4
320-189	None	L79K	0.110	0.040	0
320-190	None	L79W	0.020	0.040	2
320-191	None	L79Y	0.020	0.040	2
320-198	None	T24L	0.010	0.010	1
320-201	None	S25A	0.005	0.010	2
320-202	None	S25Q	0.010	0.010	1
320-205	None	S25K	0.020	0.030	2
320-207	None	S25W	0.007	0.020	3
320-209	None	S26A	0.040	0.020	1
320-211	None	S26D	0.010	0.030	3
320-213	None	S26K	0.070	0.030	0
320-219	None	S27D	0.020	0.030	2
320-226	None	S27aQ	0.030	0.020	1
320-229	None	S27aK	0.040	0.060	2
320-241	None	I27cA	0.020	0.010	1
320-244	None	I27cD	5.030	0.010	0
320-245	None	I27cH	0.540	0.010	0
320-263	None	A29K	0.003	0.010	3
320-267	None	G30A	0.010	0.040	4
320-277	None	L31S	0.003	0.010	3
320-278	None	L31Q	0.010	0.020	2
320-280	None	L31H	0.006	0.020	3
320-297	None	V33H	0.005	0.020	4
320-302	None	H34A	0.010	0.020	2
320-307	None	H34L	0.010	0.040	4

Antibody	VH Substitution relative to 320-179	VL Substitution relative to 320-179	Antibody IC₅₀ (µg/mL)	320-179 IC₅₀ (µg/mL)	Fold improvement
320-313	None	Q89H	0.020	0.030	2
320-314	None	Q89K	0.020	0.030	2
320-318	None	S90A	0.020	0.050	3
320-326	None	Y91S	0.030	0.050	2
320-328	None	Y91H	0.020	0.020	1
320-331	None	Y91W	0.002	0.020	10
320-345	None	G93K	0.020	0.010	1
320-361	None	L95D	0.010	0.010	1
320-443	Y32K	None	0.060	0.060	1
320-445	Y32W	None	0.030	0.060	2
320-463	N35A	None	0.020	0.050	3
320-464	N35S	None	0.030	0.050	2
320-477	S31H	None	0.030	0.040	1
320-547	N56Y	None	0.004	0.040	10
320-583	None	G30A, Y91W	0.003	0.080	27
320-584	None	L31S, Y91W	0.008	0.080	10
320-585	None	L31Q, Y91W	0.003	0.040	13
320-586	None	H34L, Y91W	0.002	0.050	25
320-587	N56Y	Y91W	0.001	0.040	40
320-588	N56Y	G30A	0.004	0.020	5
320-589	N56Y	L31S	0.020	0.020	1
320-590	N56Y	L31Q	0.006	0.020	3
320-591	N56Y	H34L	0.002	0.020	10
320-592	N56Y	G30A, Y91W	0.003	0.020	7
320-593	N56Y	L31S, Y91W	0.004	0.060	15
320-594	N56Y	L31Q, Y91W	0.005	0.060	12
320-595	N56Y	H34L, Y91W	0.003	0.060	20
320-601	N56Y	Y91F	0.002	0.020	10
320-611	N56Y	Y91W, G93K	0.005	0.040	8
320-613	N56Y	Y91W, G93Y	0.010	0.040	4

**** Several of the antibodies with fold improvements greater than 10 fold improvement in potency were run in up to n=7 assays. Results were consistent with the data shown in this table. Figure 7 shows n=4 replicates of several of the antibodies with improved potency compared to 320-179.**

As demonstrated in Table 12 and in Figure 6, several of the single substitution antibodies tested had superior potency compared to 320-179. Of all the single substitution antibody variants tested two had greater than 10 fold improvement in potency when compared to 320-179. These variants were 320-331 (which contained a Y91W substitution in the variable light chain) and 320-547 (which contained a N56Y substitution in the variable heavy chain) (Figure 6). This result is unexpected, as typically CDR3 of the antibody VH is

dominantly involved in antibody binding, while in contrast, the N56Y substitution that was identified has substantial influence on binding lies in CDR2 of the antibody VH. When variants were made incorporating either Y91W from the VL or separately N56Y in the VH with other substitutions that improved the potency, highly potent antibodies were obtained. When the Y91W VL substitution was combined with the N56Y VH substitution into one antibody, 320-587, the fold improvement in potency compared to 320-179 was 40. Figure 7 shows four different repeat experiments demonstrating the potency increase of four antibodies 320-587, 320-591, 320-592, and 320-601 compared to 320-179. The sequences of these antibodies with improved potency compared to 320-179 are shown in Figure 3 (variable heavy chain) and Figure 4 (variable light chain).

A comparison of the potency of 320-587 compared to other previously described anti-TL1A antibodies was performed. These previously described antibodies include antibody 1681N described in U.S. Pat. No. 8,642,741 (VH is SEQ ID NO: 18; VL is SEQ ID NO: 26), antibody VH5/VL1 from U.S. Publ. No. 2014/0308271 (VH is SEQ ID NO: 24; VL is SEQ ID NO: 17), humanized 1B4 as described in U.S. Pat. No. 8,263,743 (VH is SEQ ID NO: 74; VL is SEQ ID NO: 75) and 320-168 (also called C320-168) as described in U.S. Publ. No. 2014/0255302A1 (VH is SEQ ID NO: 181; VL is SEQ ID NO: 194). Figure 8 shows that 320-587 has superior potency in the cell based assay compared to these previously described antibodies, making it the most potent anti-TL1A antibody described.

2.3. DR3 and DcR3 receptor competition assays. Antibodies that displayed increased potency compared to 320-179 were screened for their ability to inhibit TL1A binding to its cognate signalling receptor, DR3, or a decoy receptor, DcR3. All anti-TL1A antibodies tested showed inhibition of TL1A binding to DR3, when compared to an isotype control (Figure 9). This confirms that the antibodies inhibit TL1A activity by blocking the TL1A – DR3 interaction.

In previous experiments described in U.S. Publ. No. 2014/0255302A1 (Example 4), antibody 320-179 (320-179) was tested in receptor competition assay and shown to selectively inhibit the binding of TL1A to DR3 by not to DcR3 (Figure 10). In experiments presented herein in Figure 10 it is again shown that 320-179 does not inhibit the TL1A-DcR3 interaction. This stands in contrast with the improved anti-TL1A antibodies tested. Antibodies with improved potency in the TF-1 cell assay (as described in Section 2.2), including antibody 320-587, consistently inhibited the TL1A-DcR3 interaction.

In summary, the parental antibody 320-179 was capable of inhibiting the TL1A-DR3 interaction but not the TL1A-DcR3 interaction. Several antibodies with improved potency such as 320-267 (VH is SEQ ID No: 1; VL is SEQ ID No: 11), 320-277 (VH is SEQ ID NO: 1, VL is SEQ ID NO 12), 320-278 (VH is SEQ ID NO 1; VL is SEQ ID NO 13) and 320-591 (VH is SEQ ID NO: 3, VL is SEQ ID NO 9) inhibited the TL1a-DR3 interaction but not the TL1A-DcR3 interaction. Several antibodies with improved potency such as 320-331, 320-547, 320-583, 320-584, 320-585, 320-586, 320-587 and variants of these antibodies, are capable of inhibiting both the TL1A-DR3 and the TL1A-DcR3 interaction.

2.4. Species cross-reactivity of 320-587 was tested for its ability to bind to recombinantly produced TL1A from different species. The antibody bound to TL1A from all species tested (Figure 11). The binding of 320-587 to human, rat, guinea pig, dog, cat, cynomolgus monkey TL1A had a slow dissociation rate, indicating a high affinity interaction. The antibody bound mouse and rabbit TL1A and had a fast dissociation rate.

2.5. Pre-clinical efficacy models for testing anti-TL1A antibodies in the following animal models of disease:

Asthma: allergen-induced asthma – rodent (mouse, rat or guinea pig) is sensitized by intradermal injection of ovalbumin (OVA), especially OVA derived from chicken eggs, plus alum and then challenged at least 2 weeks later by aerosolized or nebulized OVA, causing asthma-like symptoms including airways hyperreactivity, influx of eosinophils and increased production of cytokines (*e.g.*, Hylkema *et al.*, 2002, Clin. Exp. Immunol. 129:390-96). Such a model could be modified by repeated challenge to present a more chronic disease profile with increased airways remodeling and fibrosis induction (*e.g.*, Bos *et al.*, 2007, Eur. Respir. J. 30:653-661). Alternative allergens, such as house dust mite, may also be used (*e.g.*, Lambert *et al.*, 1998, Am. J. Respir. Crit. Care Med. 157:1991-9). Alternatively, a nonhuman primate (*e.g.*, cynomolgus macaque) may be sensitized and challenged with an environmental antigen such as *Ascaris suum*, leading to airways hyperreactivity, influx of eosinophils and increased production of cytokines (*e.g.*, Wegner *et al.*, 1991, J. Allergy Clin. Immunol. 87:835-41).

COPD: Smoke inhalation-induced airways inflammation – rodent (mouse, rat or guinea pig) will be exposed to cigarette smoke 3-7 times a week for at least 4 weeks causing a pulmonary disease similar to COPD, characterized by lung accumulation of neutrophils, increased inflammatory cytokine production, lung fibrosis and pulmonary hypertension

(*e.g.*, Davis *et al.* (2012) PLoS One 7:e33304). A more severe form of disease may be induced by including repeat bacterial or viral infection into the lungs during smoke exposure (*e.g.*, Li *et al.* (2012) Biol. Pharm. Bull. 35:1752-60). Rodents with smoke-induced COPD will be treated with anti-TL1A antibodies and screened for treatment efficacy.

Pulmonary fibrosis: Bleomycin-induced pulmonary fibrosis – rodent (mouse, rat or guinea pig) will be treated with bleomycin either by intratracheal/intranasal instillation or intravenous injection once or twice weekly for at least 3 weeks. This treatment induces significant and stable pulmonary fibrosis (*e.g.*, Pinart *et al.* (2009) Resp. Physiol. Neurobiol. 166:41-46). Rodents with bleomycin-induced pulmonary fibrosis will be treated with anti-TL1A antibodies and screened for treatment efficacy.

Cystic Fibrosis: CFTR knockout ferret model – ferrets homozygous for gene knockout, or known disease-related mutations, of CFTR (causative gene in cystic fibrosis) spontaneously develop a cystic fibrosis-like disease characterized by mucus obstruction of airways, atelectasis, interstitial pneumonia and repeated lung infections with progressive lung bacterial colonization (*e.g.*, Sun *et al.* (2014) Am. J. Respir. Cell Mol. Biol. 50:502-12). CFTR^{-/-} ferrets will be treated with anti-TL1a antibodies and screened for treatment efficacy.

Irritable Bowel Syndrome: Stress-induced visceral hypersensitivity – Stress will be induced in rats by either neonatal-maternal separation (*e.g.*, Coutinho *et al.* (2002) Am. J. Physiol. Gastrointest. Liver Physiol. 282:G307-16) or restraint of adults (*e.g.*, Shen *et al.* (2010) J. Neurogastroenterol. Motil. 16:281-90). This is expected to produce altered colonic motility and visceral hypersensitivity similar to that observed in IBS patients. Stressed rats will be treated with anti-TL1A antibodies and screened for treatment efficacy.

Rheumatoid Arthritis: Collagen-induced arthritis – rodent (mouse, rat or guinea pig) will be immunized and boosted with collagen in adjuvant. Animals develop bilateral foot swelling and erythema, inflammatory infiltrate into joint area and joint damage (*e.g.*, Bendele *et al.* (1999) Toxicol. Pathol. 27:134-42). Rodents with collagen-induced arthritis will be treated with anti-TL1A antibodies and screened for treatment efficacy.

Eosinophilic esophagitis: Intranasal *Aspergillus fumigatus*-induced eosinophilic esophagitis. Mice exposed to repeat intranasal instillation of *A. fumigatis* develop marked esophageal eosinophilia, epithelial dysplasia and hyperplasia, and free eosinophil granules (*e.g.*, Mishra *et al.* (2001) J. Clin. Invest. 107:83-90). Similarly, repeat aerosol exposure to ovalbumin over a two week period in sensitized guinea pigs causes esophageal eosinophilia

with infiltration of both eosinophils and mast cells into the epithelial layer (*e.g.*, Liu *et al.* (2015) Am. J. Physiol. Gastrointest. Liver Physiol. 308:G482-488). Mice or guinea pigs with eosinophilic esophagitis will be treated with anti-TL1A antibodies and screened for treatment efficacy.

2.6. Use of TL1A antibodies in detecting samples containing TL1A antibodies of the disclosure can be used to detect TL1A in human samples. 320-587 was used to detect human TL1A secreted from human PBMCs stimulated with immune complexes (Figure 13) in ELISA format. 320-587 was also used to detect a population of human PBMCs that express membrane TL1A on their surface in flow cytometry experiments (Figure 14).

2.7. Affinity measurements of Anti-TL1A antibody binding to human TL1A by kinetic exclusion assay. Time to reach equilibrium with 320-587 as CBP: First, the K_{on} rate for the 320-587/TL1A interaction was measured. Briefly, a solution was prepared by mixing 320-587 and TL1A, and aliquots were removed at various time points over 3 hours. Free 320-587 was captured by passing the solution over a column packed with Sepharose beads coated with 20 $\mu\text{g/mL}$ TL1A. Captured 320-587 was detected with an Alexa Fluor® 647-conjugated anti-human antibody (0.5 $\mu\text{g/mL}$). This assay was repeated two times yielding K_{on} rates of $8.35 \times 10^5 \text{ Ms}^{-1}$ and $7.45 \times 10^5 \text{ Ms}^{-1}$, with an average K_{on} rate of $7.90 \times 10^5 \text{ Ms}^{-1}$. The K_{on} rate was then used to estimate the amount of time required to reach equilibrium at various concentrations of 320-587 using the theoretical binding curve tool provided on the Sapidyne website (www.Sapidyne.com).

KD determination with 320-587 as CBP. The CBP, 320-587, was diluted in assay buffer (DPBS supplemented with 1 mg/ml BSA) to final concentrations of 15, 50 and 150 pM. The titrant, human TL1A was diluted in assay buffer to create a concentration series of 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000 and 3000 pM. Using the time to reach equilibrium determined above, curves that contained either 50 or 150 pM 320-587 were allowed to come to equilibrium in a 25°C incubator for 2 days. Curves that contained 15 pM 320-587 were allowed to come to equilibrium in a 25°C incubator for 3 days. Following the equilibration period, the free fraction of 320-587 in each reaction was quantitated as described in above. The K_D values were determined using n-curve analysis of equilibrium curves generated with 15, 50 and 150 pM 320-587.

Time to reach equilibrium with TL1A as CBP: The time to reach equilibrium in this orientation was estimated using the K_{on} for the 320-587/TL1A interaction, determined as

described in 2.8 above. In this format, the free fraction of TL1A was captured by passing the solution over a column packed with PMMA beads coated with 30 µg/mL 320-587. Captured TL1A was detected with an anti 6x-his DyLight 650 antibody (0.75 µg/mL). This assay was repeated two times yielding K_{on} rates of $6.11 \times 10^5 \text{ Ms}^{-1}$ and $5.74 \times 10^5 \text{ Ms}^{-1}$, with an average K_{on} rate of $5.93 \times 10^5 \text{ Ms}^{-1}$.

K_D determination with TL1A as CBP: The CBP, human TL1A, was diluted in assay buffer to final concentrations of 30, 100 and 300 pM. The titrant, 320-587, was diluted in assay buffer to create a concentration series of 0.05, 0.15, 0.5, 1.5, 5, 15, 50, 150, 500, 1500 and 5000 pM.

Using the time to reach equilibrium determined above, all curves were allowed to come to equilibrium in a 25°C incubator for 3 days. Following the equilibration period, the free fraction of TL1A in each reaction was quantitated as described above. The K_D values were determined using n-curve analysis of equilibrium curves generated with 30, 100 and 300 pM TL1A.

Good agreement was observed between the two KinExA methods as well as a relatively low % error. The K_D value for the interaction of TL1A with 320-587 determined using 320-587 as the CBP was $40.97 \pm 8.33 \text{ pM}$ (Table 13), while the K_D obtained using TL1A as the CBP was $41.52 \pm 13.5 \text{ pM}$ (Table 14).

Table 13. Affinity: Sepharose beads coated with TL1A; 320-587 as the CBP.

Assay No:	K_D (pM)	% Error
1	40.43	4.57
2	52.03	5.61
3	46.31	4.76
4	32.42	3.74
5	33.66	3.9
Average	40.97	
SD	8.33	
%CV	20	

Table 14. Affinity: PMMA beads coated with 320-587; TL1A as the CBP.

Assay No:	K_D (pM)	% Error
1	33.39	5.33
2	57.1	5.51
3	34.07	3.9

Average	41.52	
SD	13.5	
%CV	33	

3.0. Preclinical efficacy models for testing anti-TL1a antibodies.

3.0.1. Asthma.

Acute ovalbumin-induced asthma in rats. Brown-Norway rats were sensitized with OVA by i.p. injection on day 0 then challenged with OVA aerosol daily on days 35-42. Rats were treated with antibody 320-587 or vehicle by i.v. injection on days 14, 21, 28 and 35. Bronchoalveolar lavage fluid (BALF) was assessed for total and differential cells on day 43. Treatment was found to significantly reduce BALF eosinophils (Figure 15).

Chronic ovalbumin-induced asthma in rats. Rats were sensitized with OVA plus alum by i.p. injection on days 0 and 7, and then challenged with OVA aerosol twice weekly for 3 weeks starting on day 14 through day 31, and on 5 consecutive days from days 37 to 42. Animals were treated with antibody 320-587 or vehicle i.v. on days 24, 29, 34 and 39. BALF was assessed for total and differential cells, and a panel of cytokines on day 43. Lung sections were stained with hematoxylin and eosin (H&E), and periodic-acid Schiff (PAS), and assessed for a range of pathologies. Treatment with 320-587 significantly decreased BALF eosinophils and macrophages (Figure 17A and 17B), BALF IL-4 and IL-13 (Figure 17C), goblet cell hyperplasia (Figure 17D) and the thickness of the bronchial epithelial layer (Figure 17E), compared to the vehicle.

Acute ovalbumin-induced asthma in guinea pigs. Male Dunkin Hartley guinea pigs were sensitized to ovalbumin and thereafter underwent surgery to install a balloon catheter to measure lung function and early and late asthmatic reactions. On day 16, 20, 24 and 28, animals were treated i.p. with antibody 320-587 or vehicle. Challenge with ovalbumin (0.05-0.1%) aerosol was performed 30 minutes after the last treatment. Airway responsiveness (AHR) to histamine was measured 24h before challenge, 6h after challenge (directly after the early asthmatic reaction) and 24h after challenge (directly after the late asthmatic reaction). The nature and size of the early and late asthmatic reactions was also be recorded by online registration of lung function over the entire 24h period. Animals were sacrificed 25h after challenge and bronchoalveolar lavage performed. BALF was assessed for total and differential cells. Treatment with 320-587 significantly decreased both eosinophils and

macrophages in BALF (Figure 16A and 16B) as well as ameliorating AHR after the early asthmatic reaction (Figure 16C) and the overall magnitude of the early asthmatic reaction (Figure 16D), as compared to vehicle.

Chronic ovalbumin-induced asthma in guinea pigs. Male Dunkin Hartley guinea pigs were sensitized to ovalbumin, and 4 weeks thereafter challenged with ovalbumin weekly for 12 weeks. Ovalbumin challenge (0.05-0.5%) was performed by inhalation of aerosolized solution until airway obstruction was observed. Animals were treated with antibody 320-587 or vehicle i.p. every 5 days starting week 8 of ovalbumin challenges. Airways function, by means of airways responsiveness to histamine, was measured before the initial challenge, 24 hours before the final challenge, and 6 hours after the final challenge. Although no effect on AHR induced by histamine challenge was observed, antibody 320-587 significantly decreased the allergic response to OVA, as progressively increasing doses of OVA were required to induce airways obstruction (Figure 18).

The differences in antibody therapeutic effect observed in the acute and chronic asthma models in guinea pigs is believed to be a function of the model itself. It is believed that in the chronic model, the degree of AHR decreases over time and, accordingly, becomes less responsive to treatment. In the art, the acute model is generally used to observe compound effects on airways responsiveness, and the chronic model is generally used to observe compound effects on airways remodelling. Remodelling assessments are ongoing. Nevertheless, it was surprising to observe the antibodies having an impact on the response to allergen - although the antibody didn't substantially impact absolute AHR (response to histamine) at this stage, it had significantly decreased the direct allergic response to antigen.

3.0.2. Inflammatory Bowel Disease

TNBS-induced colitis in rats: Rats were treated with a single dose of tri-nitrobenzenesulfonic acid in ethanol by intrarectal instillation dose. Control animals received equivalent volume of ethanol only. Over a space of 7 days, animals developed focal colitis characterized by ulceration of the colon with inflammatory infiltrate and varying degrees of fibrosis (*e.g.*, Wirtz *et al.* (2007) Nat. Protoc. 2:541-546). 320-587 administration significantly reduced multiple disease indicators including colon thickness (Figure 12A), number and severity of adhesions (Figure 12B), and number and severity of strictures (Figure 12C) leading to a significantly milder disease than animals treated with either vehicle

or an isotype-matched irrelevant antibody (Figure 12D). Decreased colon fibrosis (Figure 19) was also observed in 320.587 treated animals.

Comparison of disease after 7 and 14 days in DNBS-induced colitis in rats. Colitis was induced as described above using dinitrobenzenesulfonic acid (DNBS) instead of TNBS, and the rats used in the DNBS experiments were Wistar rats. Animals were treated with antibody 320-587 or vehicle i.v. on days 1 and 8. Groups were assessed for colitis 7 and 14 days post-DNBS and disease severity compared between the two timepoints. Treatment with antibody 320-587 had limited effect on day 7, but by day 14, animals treated with antibody 320-587 showed significant improvement in colon weight and length (Figure 20A), fibrosis (Figure 20B), inflammatory infiltrate (Figure 20C) and colon damage (Figure 20D). Representative sections of ulcer area colon (Figure 20E) show the extent of damage repair and reduction in fibrosis at 14 days. At both 7 and 14 days, vehicle-treated animals showed extensive inflammatory infiltrate and fibrosis with significant loss of intestinal architecture. In contrast, 320-587-treated animals showed significant inflammatory infiltrate, fibrosis and loss of intestinal architecture at 7 days but these effects are largely reversed by 14 days.

The differences observed in the antibody therapeutic effects observed in the TNBS and DNBS models are believed to arise from the use of different strains of rats (Sprague-Dawley for TNBS versus Wistar for DNBS). Each rat strain has differences in their responses to immunological challenges such that the kinetics of their response in these models is believed to be different. As well, TNBS and DNBS are different structurally, and are believed to induce variations in the disease state.

Chronic (21 day) DSS-induced colitis in rats. Rats were given dextran sulfate sodium (DSS) at a concentration of 5% w/v in drinking water for 7 days, then 2% w/v in drinking water for a further 14 days. Animals developed diarrhea, diffuse colonic inflammation, goblet cell hyperplasia, and crypt epithelial damage and ulceration (*e.g.* Randhawa *et al.* (2014) Korean J. Physiol. Pharmacol. 18:279-88). Rats were treated with antibody 320-587 or vehicle by intravenous injection on days 5, 12 and 19. Animals were weighed and assessed for clinical disease (diarrhea and occult blood) daily, and colon weight and length were assessed on day 21. Antibody 320-587 treatment significantly reversed DSS-induced slowdown of weight gain (Figure 21A), ameliorated clinical signs of disease (Figure 21B) and improved colon weight and length (Figure 21C).

Induction of intraperitoneal cytokines by recombinant human TL1A. Intraperitoneal injection of recombinant mouse TL1A can induce the production of inflammatory cytokines such as IL-5. In this study, mice received a single dose of either antibody 320-587 or vehicle then an hour later were treated with recombinant human TL1A (rhTL1A) 40 µg/mouse. Six hours after rhTL1A dosage, peritoneal lavage was performed and the peritoneal fluid assessed for cytokines and chemokines by multiplex assay. Treatment with antibody 320-587 significantly decreased peritoneal concentrations of cytokines G-CSF, IL-1b, IL-5, IL-6, IL-17, and chemokines IP-10, KC, MCP-1, MIP-1a, MIP-1b, MIP-2 (Figure 22).

The disclosure is not limited to the embodiments described and exemplified above, but is capable of variation and modification within the scope of the appended claims.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

We claim:

1. A recombinant antibody, comprising a heavy chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 15, a heavy chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 21, a heavy chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 17, a light chain variable region CDR1 comprising the amino acid sequence of SEQ ID NO: 18, a light chain variable region CDR2 comprising the amino acid sequence of SEQ ID NO: 19, and a light chain variable region CDR3 comprising the amino acid sequence of SEQ ID NO: 22, wherein the antibody specifically binds to TNF-like ligand 1A (TL1A).
2. The recombinant antibody according to claim 1, wherein the antibody is capable of inhibiting the interaction of TL1A with the death receptor 3 (DR3).
3. The recombinant antibody according to claim 1, wherein the antibody is a monoclonal antibody.
4. A composition, comprising the recombinant antibody of claim 1 and a pharmaceutically acceptable carrier, wherein the composition is formulated for administration to a human subject.
5. The recombinant antibody according to claim 1, wherein the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO:3.
6. The recombinant antibody according to claim 1, wherein the antibody comprises a light chain variable region comprising the amino acid sequence of SEQ ID NO:4.
7. The recombinant antibody according to claim 1, wherein the antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO:3 and a light chain variable region comprising the amino acid sequence of SEQ ID NO:4.
8. The recombinant antibody according to claim 1, wherein the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO:60.

9. The recombinant antibody according to claim 1, wherein the antibody comprises a light chain comprising the amino acid sequence of SEQ ID NO:61.
10. The recombinant antibody according to claim 6, wherein the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 60.
11. The recombinant antibody according to claim 5, wherein the antibody comprises a light chain comprising the amino acid sequence of SEQ ID NO: 61.
12. The recombinant antibody according to claim 1, wherein the antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 60 and a light chain comprising the amino acid sequence of SEQ ID NO: 61.
13. The recombinant antibody according to claim 1 wherein the antibody comprises a heavy chain constant region comprising the amino acid sequence of SEQ ID NO: 43.
14. The recombinant antibody according to claim 1, wherein the antibody comprises a light chain constant region comprising the amino acid sequence of SEQ ID NO: 48.
15. The recombinant antibody according to claim 1, wherein the antibody comprises a human IgG1 heavy chain constant region and a human light chain lambda constant region.
16. The recombinant antibody according to claim 6, wherein the antibody comprises a heavy chain constant region comprising the amino acid sequence of SEQ ID NO:43.
17. The recombinant antibody according to claim 11, wherein the antibody comprises a heavy chain constant region comprising the amino acid sequence of SEQ ID NO:43.
18. The recombinant antibody according to claim 5, wherein the antibody comprises a light chain constant region comprising the amino acid sequence of SEQ ID NO:48.

19. The recombinant antibody according to claim 8, wherein the antibody comprises a light chain constant region comprising the amino acid sequence of SEQ ID NO:48.
20. A transformed host cell that comprises a polynucleotide encoding the antibody according to claim 1 and which expresses said antibody.
21. A method of making an antibody comprising culturing the host cell according to claim 20.
22. An *in vitro* method of detecting TL1A in a sample obtained from a subject comprising contacting the sample with the antibody of claim 1 and detecting the antibody bound to TL1A in the sample.
23. A polynucleotide comprising a nucleic acid sequence encoding an antibody heavy chain variable region comprising the amino acid sequence of SEQ ID NO:3.
24. A host cell comprising a vector comprising the polynucleotide of claim 23.
25. A polynucleotide comprising a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO:4.
26. A host cell comprising a vector comprising the polynucleotide of claim 25.
27. The host cell of claim 26 further comprising a polynucleotide comprising a nucleic acid sequence encoding an antibody light chain variable region comprising the amino acid sequence of SEQ ID NO:4.
28. The recombinant antibody according to claim 1, wherein the antibody comprises a human IgG1 heavy chain constant region.
29. The recombinant antibody according to claim 28, wherein the human IgG1 heavy chain constant region comprises SEQ ID NO: 42, SEQ ID NO: 43, SEQ ID NO: 44, SEQ ID NO: 62, SEQ ID NO: 63, SEQ ID NO: 64, SEQ ID NO: 65, or SEQ ID NO: 66.

30. The recombinant antibody according to claim 1, wherein the antibody comprises a human heavy chain IgG4 constant region.
31. The recombinant antibody according to claim 30, wherein the human heavy chain IgG4 constant region comprises SEQ ID NO: 45, SEQ ID NO: 46, SEQ ID NO: 47, or SEQ ID NO: 69.
32. The recombinant antibody according to claim 1, wherein the antibody comprises a human heavy chain IgG2 constant region.
33. The recombinant antibody according to claim 32, wherein the human heavy chain IgG2 constant region comprises SEQ ID NO: 67, SEQ ID NO: 68, SEQ ID NO: 70, or SEQ ID NO: 71.
34. The recombinant antibody according to claim 1, wherein the antibody comprises a human light chain lambda constant region.
35. Use of a composition comprising the recombinant antibody of claim 1 and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a respiratory tract disease selected from asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pulmonary sarcoidosis, allergic rhinitis, and cystic fibrosis, wherein the medicament is formulated for administration to a human subject.
36. The use of claim 35 for treating asthma.
37. Use of a composition comprising the recombinant antibody of claim 1 and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a gastrointestinal disease selected from inflammatory bowel disease, Crohn's disease, colitis, ulcerative colitis, eosinophilic esophagitis, irritable bowel syndrome, and gastrointestinal disease associated with cystic fibrosis, wherein the medicament is formulated for administration to a human subject.

38. Use of a composition comprising the recombinant antibody of claim 1 and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating arthritis, wherein the medicament is formulated for administration to a human subject.
39. The use of claim 38, wherein the arthritis is rheumatoid arthritis.
40. Use of a composition comprising the recombinant antibody of claim 1 and a pharmaceutically acceptable carrier in the manufacture of a medicament for treating a skin disease selected from atopic dermatitis, eczema, and scleroderma, wherein the medicament is formulated for administration to a human subject.