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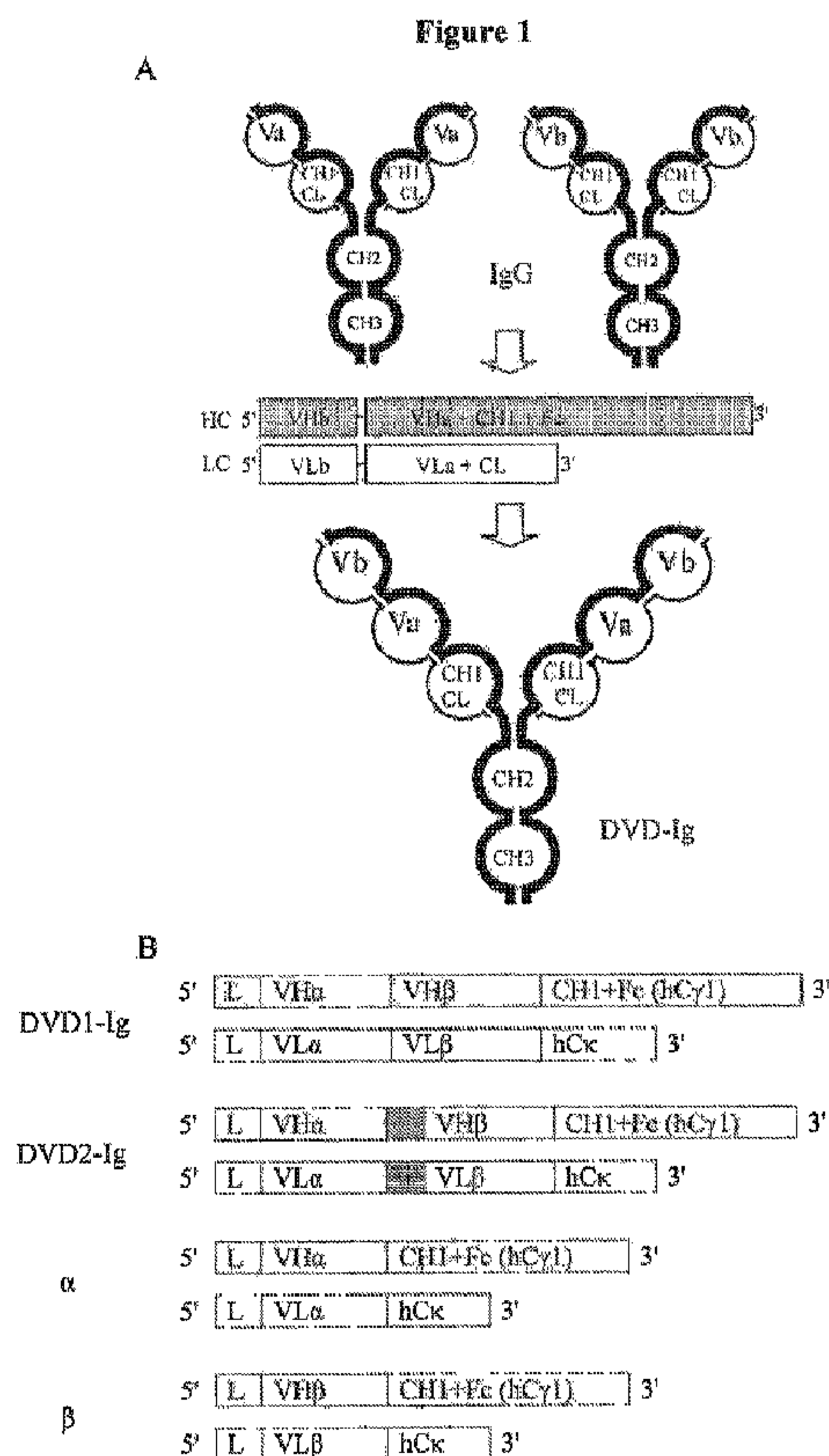
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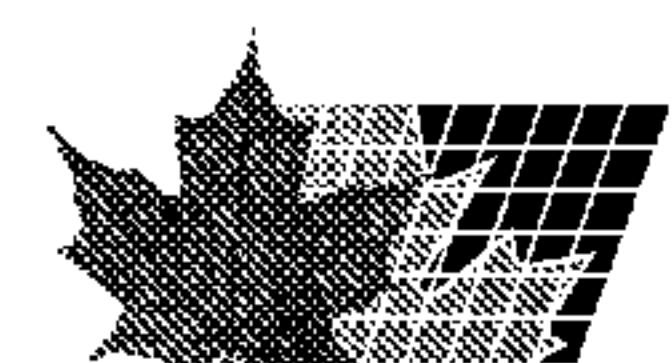
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(54) **Titre : PROTEINES DE LIAISON SPECIFIQUES A DOMAINES VARIABLES DOUBLES DIRIGÉES CONTRE IL-1 β ET/OU IL-17**
(54) **Title: DUAL SPECIFIC BINDING PROTEINS DIRECTED AGAINST IL-1 β AND/OR IL-17**

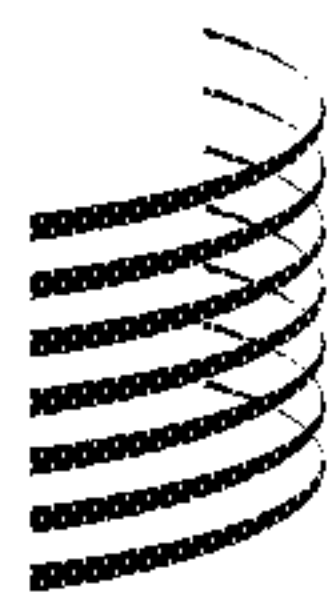


(57) **Abrégé/Abstract:**

Engineered multivalent and multispecific binding proteins that bind IL-1 β and/or IL-17 are provided, along with methods of making and using the binding proteins in the prevention, diagnosis, and/or treatment of disease.



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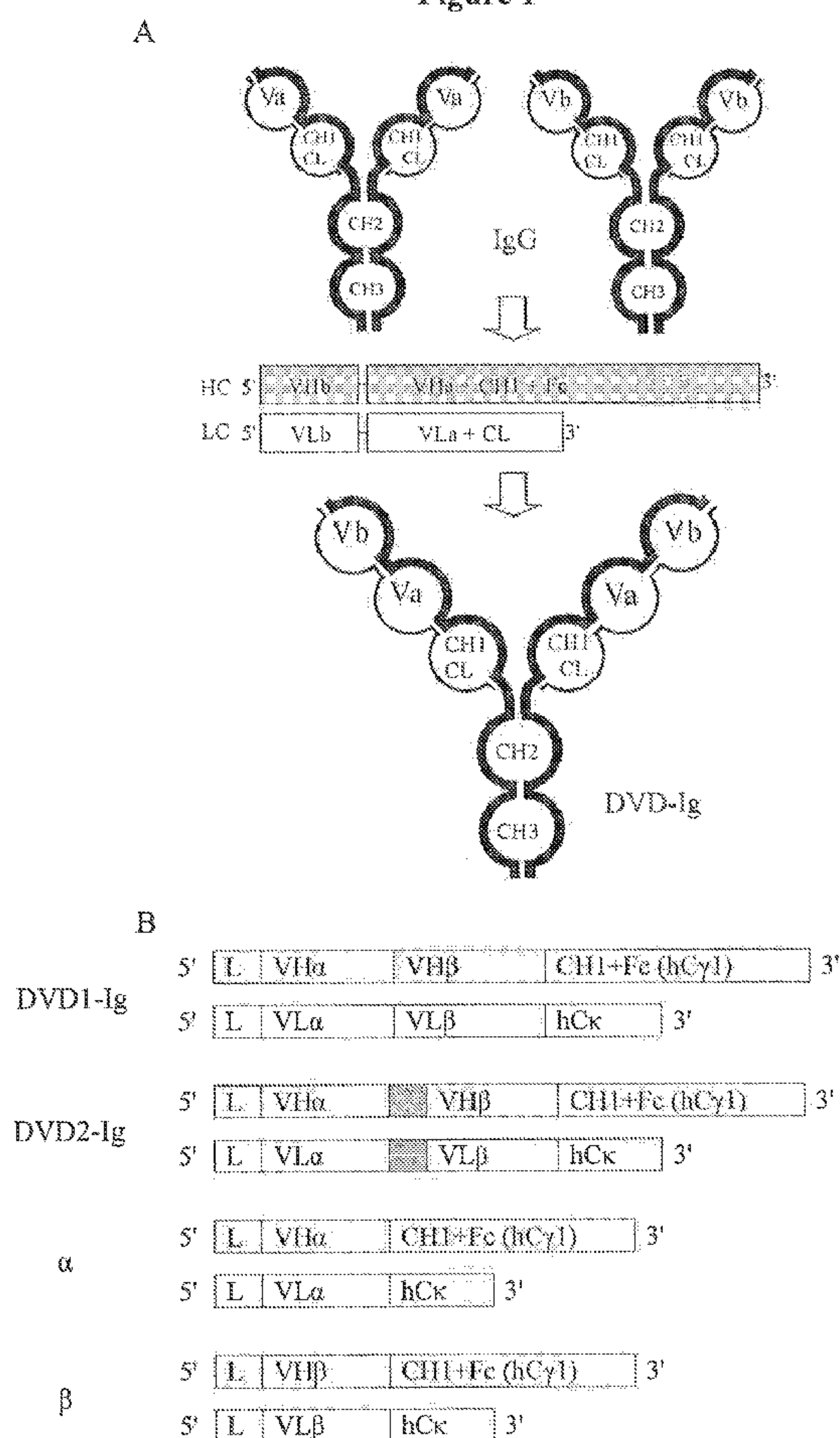
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[Continued on next page]

(54) Title: DUAL SPECIFIC BINDING PROTEINS DIRECTED AGAINST IL-1 BETA AND IL-17

Figure 1

(57) Abstract: Engineered multivalent and multispecific binding
proteins that bind 1 L-1β and/or IL-17 are provided, along with
methods of making and using the binding proteins in the prevention,
diagnosis, and/or treatment of disease.

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**DUAL SPECIFIC BINDING PROTEINS
DIRECTED AGAINST IL-1 β and/or IL-17**

[001] This application claims priority to U.S. Provisional Application Serial No. 61/799,700, filed March 15, 2013, which is hereby incorporated by reference in its entirety.

[002] Multivalent and multispecific binding proteins that bind IL-1 β and/or IL-17, methods of making, and their uses in the diagnosis, prevention, and/or treatment of acute and chronic inflammatory diseases, cancer, and other diseases are provided.

[003] Engineered proteins, such as multispecific binding proteins capable of binding two or more antigens, are known in the art. Such multispecific binding proteins can be generated using cell fusion, chemical conjugation, or recombinant DNA techniques. There are a variety of multispecific binding protein structures known in the art and many structures and methods have distinct disadvantages.

[004] Bispecific antibodies have been produced using quadroma technology. However, the presence of mis-paired by-products and significantly reduced production yields with this technology means that sophisticated purification procedures are required. Bispecific antibodies can also be produced by chemical conjugation of two different mAbs. However, this approach does not yield homogeneous preparations.

[005] Other approaches used previously include coupling of two parental antibodies with a hetero-bifunctional crosslinker, production of tandem single-chain Fv molecules, diabodies, bispecific diabodies, single-chain diabodies, and di-diabodies. However, each of these approaches has disadvantages. In addition, a multivalent antibody construct comprising two Fab repeats in the heavy chain of an IgG and capable of binding four antigen molecules has been described (see PCT Publication No. WO 0177342 and Miller et al. (2003) J. Immunol. 170(9): 4854-61).

[006] US Patent No. 7,612,181 (incorporated herein by reference in its entirety) provides a novel family of binding proteins capable of binding two or more antigens with high affinity, which are called dual variable domain binding proteins (DVD-Ig binding protein) or dual variable domain immunoglobulins (DVD-IgTM). DVD-Ig molecules are binding proteins that may be used to bind two distinct epitopes on the same molecule or two different molecules simultaneously. DVD-Ig molecules are

unique binding proteins comprised of two variable domains fused to N-terminal constant regions. The variable domains may be directly fused to one another or connected via synthetic peptide linkers of assorted length and amino acid composition. DVD-Ig binding proteins may be engineered with intact and functional Fc domains, allowing them to mediate appropriate effector functions. The DVD-Ig format, due to its flexibility of choice of variable domain pair, orientation of two antigen-binding domains, and the length of the linker that joins them, may provide novel therapeutic modalities.

[007] While a variety of structures are provided in the art, some with advantages and disadvantages, specific constructs are required for preparing multivalent binding proteins with specific properties and which bind to specific targets. Additionally, new variable domain sequences can further improve the properties of binding proteins. For example, there remains a need for constructs exhibiting better targeting and/or desired efficiency of binding to IL-1 β and/or IL-17, e.g., to prevent, diagnose, and/or treat autoimmune, inflammatory, or neurological disorders. There is thus a need in the art for improved multivalent binding proteins capable of binding IL-1 β and/or IL-17, and/or improved multivalent binding proteins capable of neutralizing IL-1 β and/or IL-17.

[008] Accordingly, disclosed herein are dual variable domain immunoglobulins using the binding protein framework disclosed in US Patent No. 7,612,181 (incorporated herein by reference in its entirety) and containing particular first and second polypeptide chains, each comprising first and second variable domains comprising sequences (e.g., sequences selected from those listed in Table 1) that form functional binding sites for binding targets such as IL-1 β and/or IL-17. In some embodiments, the first and second polypeptide chains of the binding protein each independently comprise VD1-(X1) n -VD2-C-X2, wherein: VD1 is a first variable domain; VD2 is a second variable domain; C is a constant domain; X1 is a linker; X2 is an Fc region that is either present or absent; n is 0 or 1, and wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site for IL-1 β or IL-17 and the VD2 domains on the first and second polypeptide chains form a second functional target binding site for IL-1 β or IL-17. In some embodiments, an Fc domain is present on one polypeptide chain and absent on the other, or absent on both polypeptide chains. In some embodiments, the sequences of the first and second variable domains on each polypeptide chain (i.e., VD1 and VD2) are selected from the sequences in Table 1 to form functional binding

sites. In some embodiments, the sequences of the first and second variable domains each contain the three CDRs (i.e., CDRs 1-3) from the selected sequences listed in Table 1 and are arranged in the same order as shown in Table 1, thereby forming functional binding sites (i.e., the binding domains are capable of binding to their target antigen, IL-1 β or IL-17). In some embodiments, the paired variable domain sequences on the first and second polypeptide chains (i.e., the VD1 sequence on the first chain paired with the VD1 sequence on the second chain and the VD2 sequence on the first chain paired with the VD2 sequence on the second chain) form functional binding sites for binding targets IL-1 β and/or IL-17. In some embodiments, the binding proteins are capable of binding to IL-1 β and/or IL-17 with improved binding affinity and/or neutralization potency.

Brief Description of the Drawings

[009] Figure 1 is a schematic representation of Dual Variable Domain (DVD) binding protein constructs.

Detailed Description

[010] The IL-1 superfamily is comprised of mediators of inflammatory processes having a wide range of biological and physiological effects, including fever, prostaglandin synthesis (in, e.g., fibroblasts, muscle cells and endothelial cells), T-lymphocyte activation, and interleukin-2 production. The original members of the IL-1 superfamily are IL-1 α , IL-1 β , and the IL-1 Receptor Antagonist (IL-1Ra, IL-1RA, IL-1ra, IL-1R α). IL-1 α and IL-1 β are pro-inflammatory cytokines involved in immune defense against infection. Both IL-1 α and IL-1 β are produced by macrophages, monocytes, and dendritic cells. These cytokines increase the expression of adhesion factors on endothelial cells to enable transmigration of leukocytes to sites of infection and re-set the hypothalamus thermoregulatory center, leading to an increased body temperature which expresses itself as fever. IL-1 is therefore often referred to as an endogenous pyrogen. IL-1 is also important in the regulation of hematopoiesis. IL-1 β production in peripheral tissue has also been associated with hyperalgesia (increased sensitivity to pain) associated with fever (Morgan et al. (2004) Brain Res. 1022(1-2):96–100). IL-1 upregulates expression of cyclooxygenase-2 (COX-2) associated with pain. IL-1 α and IL-1 β also possess similar biological properties, including induction of fever, slow wave sleep, and neutrophilia, T- and B-lymphocyte activation, fibroblast proliferation, cytotoxicity for certain cells, induction of collagenases,

synthesis of hepatic acute phase proteins, and increased production of colony stimulating factors and collagen.

[011] Interleukin-17 (IL-17, also referred to as IL-17A) is a 20-30 kD homodimeric glycoprotein secreted by activated T cells at the site of inflammation. IL-17 acts as a proinflammatory cytokine by inducing the production of multiple adhesion molecules, inflammatory cytokines and chemokines in various tissues to recruit monocytes and neutrophils to the site of inflammation. IL-17 also plays an important role in the maturation of hematopoietic progenitor cells. Inappropriate or excessive production of IL-17 is associated with the pathology of various diseases or disorders including rheumatoid arthritis, asthma, lupus, allograft rejection, other inflammatory or autoimmune diseases and cancer.

[012] Disclosed herein are improved binding proteins against IL-1 β and/or IL-17.

Binding Proteins

[013] In some embodiments, a binding protein is disclosed comprising first and second polypeptide chains, each independently comprising VD1-(X1) n -VD2-C-X2, wherein: VD1 is a first variable domain; VD2 is a second variable domain; C is a constant domain; X1 is a linker; X2 is an Fc region that is either present or absent; n is independently 0 or 1 on the first and second chains, and wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site. In some embodiments, the binding protein is capable of binding IL-1 β and/or IL-17. In some embodiments, the binding protein comprises VD1 sequences on the first and second polypeptide chains (i.e., a VD1 sequence on the first chain paired with a VD1 sequence on the second chain) that together form a binding domain capable of binding a target selected from IL-1 β and IL-17. In some embodiments, the binding protein is capable of binding IL-1 β at both the VD1 and VD2 positions. In some embodiments, the binding protein is capable of binding IL-17 at both the VD1 and VD2 positions. In some embodiments, the binding protein is capable of binding IL-1 β at the VD1 position and IL-17 at the VD2 position. In some embodiments, the binding protein is capable of binding IL-17 at the VD1 position and IL-1 β at the VD2 position.

[014] The binding proteins disclosed herein comprise VD1 and VD2 binding domains that are capable of binding to first and second target antigens. As used

herein, a VD1 domain or a VD2 domain, or a VD1 position or VD2 position, may refer to either the variable domain sequence on one polypeptide chain (e.g., a VD1 heavy chain sequence) or to the variable domain sequences on both the first and second polypeptide chain (e.g., a VD1 heavy chain sequence and a VD1 light chain sequence) that together form the functional binding site.

[015] In some embodiments, the VD1 sequences that form the VD1 binding site are selected from the paired sequences in Table 1 (for example, the paired sequences of SEQ ID NO: 32 and 33 in Table 1 that together form a binding site for IL-1 β). In some embodiments, the VD2 sequences that form the VD2 binding site are selected from the paired sequences in Table 1 (for example, the paired sequences of SEQ ID NO: 32 and 33 in Table 1 that together form a binding site for IL-1 β). In some embodiments, the VD1 and/or VD2 sequences comprise CDRs 1-3 of the sequences selected from Table 1 but have different variable domain framework sequences (e.g., variable domains that are CDR grafted, affinity matured, humanized, humanized and backmutated, or other functional variants of the sequences disclosed in Table 1).

[016] The CDR sequences of the variable domains in Table 1 are underlined. In that regard, for SEQ ID NO: 32, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-66, and the CDR3 sequence can be found at amino acid positions 99-108. For SEQ ID NO: 33, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 34, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-66, and the CDR3 sequence can be found at amino acid positions 99-108. For SEQ ID NO: 35, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 36, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-65, and the CDR3 sequence can be found at amino acid positions 98-111. For SEQ ID NO: 37, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 38, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-65, and the CDR3 sequence can be found at amino acid positions 98-111. For

SEQ ID NO: 39, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 40, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-65, and the CDR3 sequence can be found at amino acid positions 98-111. For SEQ ID NO: 41, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 42, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-66, and the CDR3 sequence can be found at amino acid positions 99-110. For SEQ ID NO: 43, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 44, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-66, and the CDR3 sequence can be found at amino acid positions 99-115. For SEQ ID NO: 45, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97. For SEQ ID NO: 46, the CDR1 sequence can be found at amino acid positions 31-35, the CDR2 sequence can be found at amino acid positions 50-66, and the CDR3 sequence can be found at amino acid positions 99-115. For SEQ ID NO: 47, the CDR1 sequence can be found at amino acid positions 24-34, the CDR2 sequence can be found at amino acid positions 50-56, and the CDR3 sequence can be found at amino acid positions 89-97.

[017] When the binding protein comprises the CDRs from a sequence selected from Table 1, the CDRs are arranged in the order specified by the sequence in Table 1 and separated by suitable framework sequences to form a functional binding site. The paired sequences selected from Table 1 that form a functional binding site for a target (i.e., a binding site for IL-1 β or IL-17), or the CDRs from those sequences, may be placed in either the VD1 or VD2 positions on the first and second polypeptide chains to form a binding site at either the VD1 or VD2 domain. For instance, matching heavy and light chain variable domain sequences from Table 1 that form a binding site for IL-1 β (e.g., SEQ ID NO: 34 and 35) can be placed in the VD1 positions on the first and second polypeptide chains to form a VD1 binding site for IL-1 β . In another example, the matching heavy and light chain sequences from

Table 1 that form a binding site for IL-1 β (e.g., SEQ ID NO: 34 and 35) can be placed in the VD2 positions on the first and second polypeptide chains to form a VD2 binding site for IL-1 β . The same or different sequences may occupy both the VD1 and VD2 positions. For example, SEQ ID NO: 34 and 35 may be used to form a binding domain at the VD1 position and at the VD2 position, or SEQ ID NO: 34 and 35 may form the binding domain at one of the VD1 and VD2 positions, while a different sequence pair can be selected to form the binding domain at the other position. Similarly, any of the other sequence pairs in Table 1 may be selected for use in either or both of the VD1 and VD2 positions on the first and second polypeptide chains.

[018] In some embodiments, the variable domain sequences on the first and second polypeptide chains that form a functional target binding site for IL-1 β in a binding protein (i.e., at the VD1 and/or VD2 positions) can comprise the paired variable domain sequences selected from those in Table 1 or CDRs 1-3 from those sequences. For instance, the variable domains that form a functional target binding site for IL-1 β can comprise SEQ ID NO: 32 and SEQ ID NO: 33, SEQ ID NO: 34 and SEQ ID NO: 35, SEQ ID NO: 36 and SEQ ID NO: 37, SEQ ID NO: 38 and SEQ ID NO: 39, or SEQ ID NO: 40 and SEQ ID NO: 41, or CDRs 1-3 from those paired variable domain sequences. For example, the variable domains that form a functional target binding site for IL-1 β can comprise CDRs 1-3 from SEQ ID NO: 32 (i.e., amino acids 31-35, 50-66, and 99-108 from that sequence) on one polypeptide chain paired with CDRs 1-3 from SEQ ID NO: 33 (i.e., amino acids 24-34, 50-56, and 89-97 from that sequence) on the other chain.

[019] In some embodiments, the variable domain sequences on the first and second polypeptide chains that form a functional target binding site for IL-17 in a binding protein (i.e., at the VD1 or VD2 positions) can comprise paired heavy and light chain variable domain sequences selected from those in Table 1, or CDRs 1-3 from those selected sequences. For instance, the variable domains that form a functional target binding site for IL-17 can comprise SEQ ID NO: 42 and SEQ ID NO: 43, SEQ ID NO: 44 and SEQ ID NO: 45, or SEQ ID NO: 46 and SEQ ID NO: 47, or CDRs 1-3 from those selected variable domain sequences. For example, the variable domains that form a functional target binding site for IL-17 can comprise CDRs 1-3 from SEQ ID NO: 42 (i.e., amino acids 31-35, 50-66, and 99-110 from that sequence) on one polypeptide chain paired with CDRs 1-3 from SEQ ID NO: 43 (i.e., amino acids 24-34, 50-56, and 89-97 from that sequence) on the other chain.

[020] In certain embodiments, a binding protein is disclosed, wherein the variable domains that form a functional target binding site for IL-1beta (i.e., at the VD1 or VD2 position) comprise CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35 (i.e., CDRs 1-3 from SEQ ID NO: 34 present on one polypeptide chain at the VD1 or VD2 position and paired with CDRs 1-3 from SEQ ID NO: 35 on the other chain at the same position, with the CDRs on each chain arranged in the specified order and separated by suitable framework sequences to form a functional binding site). In an embodiment, the variable domains that form a functional target binding site for IL-17 comprise CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45 (i.e., CDRs 1-3 from SEQ ID NO: 44 present on one polypeptide chain at the VD1 or VD2 position and paired with CDRs 1-3 from SEQ ID NO: 45 on the other chain at the same position, with the CDRs on each chain arranged in the specified order and separated by suitable framework sequences to form a functional binding site). In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 34 and SEQ ID NO: 35, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 44 and SEQ ID NO: 45. In an embodiment, the X1 linker on the first polypeptide chain comprises SEQ ID NO: 29 and the X1 linker on the second polypeptide chain comprises SEQ ID NO: 30. In an embodiment, the binding protein comprises a first polypeptide chain comprising SEQ ID NO: 104 and a second polypeptide chain comprising SEQ ID NO: 105. In an embodiment, the binding protein is capable of binding IL-1 β with a K_D of at most about 3.4×10^{-11} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-1 β with an IC₅₀ of at most about 0.018 nM, as measured in an IL-1 β neutralization assay, and/or the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-17 with an IC₅₀ of at most about 0.068 nM, as measured in an IL-17 neutralization assay.

[021] In certain embodiments, a binding protein is disclosed, wherein the variable domains that form a functional target binding site for IL-1beta (i.e., at the VD1 or VD2 position) comprise CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33 (i.e., CDRs 1-3 from SEQ ID NO: 32 present on one polypeptide chain at

the VD1 or VD2 position and paired with CDRs 1-3 from SEQ ID NO: 33 on the other chain at the same position, with the CDRs on each chain arranged in the specified order and separated by suitable framework sequences to form a functional binding site). In an embodiment, the variable domains that form a functional target binding site for IL-17 comprise CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45 (i.e., CDRs 1-3 from SEQ ID NO: 44 present on one polypeptide chain at the VD1 or VD2 position and paired with CDRs 1-3 from SEQ ID NO: 45 on the other chain at the same position, with the CDRs on each chain arranged in the specified order and separated by suitable framework sequences to form a functional binding site). In an embodiment, the binding protein comprises a functional target binding site for IL-1 β comprising CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45. In an embodiment, the binding protein comprises a functional target binding site for IL-1 β (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 32 and SEQ ID NO: 33, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 44 and SEQ ID NO: 45. In an embodiment, the X1 linker on the first polypeptide chain comprises SEQ ID NO: 29 and the X1 linker on the second polypeptide chain comprises SEQ ID NO: 30. In an embodiment, the binding protein comprises a first polypeptide chain comprising SEQ ID NO: 98 and a second polypeptide chain comprising SEQ ID NO: 99. In an embodiment, the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-1 β with an IC₅₀ of at most about 0.027 nM, as measured in an IL-1 β neutralization assay, and/or the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-17 with an IC₅₀ of at most about 0.091 nM, as measured in an IL-17 neutralization assay.

[022] In an embodiment, the binding protein comprises a functional target binding site for IL-1 β comprising CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43. In an embodiment, the binding protein comprises a functional target binding site for IL-1 β (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 32 and SEQ ID NO: 33, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 42 and SEQ ID NO: 43.

[023] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 34 and SEQ ID NO: 35, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 42 and SEQ ID NO: 43.

[024] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3 from SEQ ID NO: 37, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 36 and SEQ ID NO: 37, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 42 and SEQ ID NO: 43.

[025] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 38 and SEQ ID NO: 39, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 42 and SEQ ID NO: 43.

[026] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 40 and SEQ ID NO: 41, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 42 and SEQ ID NO: 43.

[027] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3

from SEQ ID NO: 37, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 36 and SEQ ID NO: 37, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 44 and SEQ ID NO: 45.

[028] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 38 and SEQ ID NO: 39, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 44 and SEQ ID NO: 45.

[029] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 40 and SEQ ID NO: 41, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 44 and SEQ ID NO: 45.

[030] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 32 and SEQ ID NO: 33, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 46 and SEQ ID NO: 47.

[031] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47. In an embodiment, the

binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 34 and SEQ ID NO: 35, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 46 and SEQ ID NO: 47.

[032] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3 from SEQ ID NO: 37, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 36 and SEQ ID NO: 37, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 46 and SEQ ID NO: 47.

[033] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 38 and SEQ ID NO: 39, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 46 and SEQ ID NO: 47.

[034] In an embodiment, the binding protein comprises a functional target binding site for IL-1beta comprising CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41, and a functional target binding site for IL-17 comprising CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47. In an embodiment, the binding protein comprises a functional target binding site for IL-1beta (i.e., either a VD1 or VD2 binding domain) comprising SEQ ID NO: 40 and SEQ ID NO: 41, and a functional target binding site for IL-17 (i.e., either a VD2 or VD1 binding domain) comprising SEQ ID NO: 46 and SEQ ID NO: 47.

[035] In some embodiments, a binding protein as described above comprises an X1 linker on each of the first and second polypeptide chain and an X2 Fc region on one of the two chains. The X1 linkers are independently present or absent on each chain (i.e., n is independently chosen from 0 or 1 on each chain). The X1 linkers on the first and second polypeptide chains, if present, can have the same or different sequences. In one embodiment, the X1 on the first and second

polypeptide chains are short ("S") (e.g., 6 amino acid or shorter) linkers. In another embodiment, the X1 on the first and second polypeptide chains are long ("L") (e.g., greater than 6 amino acid) linkers. In another embodiment, the X1 on the first chain is a short linker and the X1 on the second chain is a long linker. In another embodiment, the X1 on the first chain is a long linker and the X1 on the second chain is a short linker. In some embodiments, the X1 linkers on the first and/or second polypeptide chains are independently selected from any one of SEQ ID NO: 1-31. In some embodiments, X1 on the first and/or second polypeptide chain of a binding protein is not a complete CH1 or CL domain, but may comprise portions of those domains. In some embodiments, X1 on the first chain is not CH1, and X1 on the second chain is not CL, or X1 on the first chain is not CL and X1 on the second chain is not CH1. In some embodiments, the choice of X1 linker on the first and/or second polypeptide chain can affect the binding kinetics of the binding protein (e.g., selecting a GS-based linker may significantly improve binding affinity and/or potency).

[036] In some embodiments, X2 (the Fc region) is present on the first polypeptide chain and absent on the second polypeptide chain, while in other embodiments X2 is present on the second chain and absent on the first chain, or X2 is absent on both the first and second chains. In some embodiments, X2 is a variant sequence Fc region. In certain embodiments, the Fc region is an Fc region from an IgG1, IgG2, IgG3, IgG4, IgA, IgM, IgE, or IgD. In some embodiments, the binding protein is a crystallized binding protein.

[037] In some embodiments, the first polypeptide chain of a binding protein, as described above, is a heavy chain, and the second polypeptide chain is a light chain. In certain embodiments, where the first polypeptide chain is a heavy chain and the second polypeptide chain is a light chain, X1 is independently present or absent on each chain (i.e., n is independently chosen from 0 or 1 on each chain), and X2 is present on the heavy chain and absent on the light chain. In some embodiments, the binding protein comprises an X1 linker on the heavy and/or light polypeptide chain that is independently selected from any one of SEQ ID NO: 1-31.

[038] In some embodiments, any of the binding proteins described above can comprise two first polypeptide chains and two second polypeptide chains and four functional binding sites. For instance, a first and second polypeptide chain may be paired on one arm of a binding protein to form two functional binding sites (at the VD1 and VD2 positions), while a second set of first and second polypeptide chains may be paired on the other arm of the binding protein to form two additional functional binding

sites (at the VD1 and VD2 positions). An example of a four chain structure having two arms, each arm comprising a first and second polypeptide chain and two functional binding sites, is shown in Figure 1. In some embodiments, the binding domains at the VD1 and VD2 positions on the first and second arms are identical. In other embodiments, the first and second arms contain different domains at the VD1 and VD2 positions. In some embodiments, the VD1 and VD2 binding domains comprise variable domain sequences selected from Table 1, or comprise the CDRs from the selected sequences.

[039] In various embodiments, binding proteins comprising first and second polypeptide chains, as described above, are capable of binding IL-1 β and/or IL-17 with a desired affinity, e.g., a high affinity or a therapeutically useful affinity. In some embodiments, the variable domain sequences that form a functional target binding site for IL-1 β (i.e., at the VD1 and/or VD2 positions) can comprise paired heavy and light chain variable domain sequences selected from those in Table 1, wherein the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-1 β with an IC50 of at most about 2.563 nM, as measured in an IL-1 β neutralization assay. For instance, the variable domains that form a functional target binding site for IL-1 β can comprise SEQ ID NO: 32 and SEQ ID NO: 33, SEQ ID NO: 34 and SEQ ID NO: 35, SEQ ID NO: 36 and SEQ ID NO: 37, SEQ ID NO: 38 and SEQ ID NO: 39, or SEQ ID NO: 40 and SEQ ID NO: 41, or CDRs 1-3 from those paired variable domain sequences. In some embodiments, the variable domain sequences that form a functional target binding site for IL-17 (i.e., at the VD1 and/or VD2 positions) can comprise paired heavy and light chain variable domain sequences selected from those in Table 1, wherein the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, and/or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, as measured in an IL-17 neutralization assay. For instance, the variable domains that form a functional target binding site for IL-17 can comprise SEQ ID NO: 42 and SEQ ID NO: 43, SEQ ID NO: 44 and SEQ ID NO: 45, or SEQ ID NO: 46 and SEQ ID NO: 47, or CDRs 1-3 from those paired variable domain sequences.

[040] In various embodiments, a binding protein having first and second polypeptide chains, as described above, and capable of binding IL-1 β and/or IL-17 comprises any one of: DVD2423 (comprising SEQ ID NOs: 48 and 49); DVD2424 (comprising SEQ ID NOs: 50 and 51); DVD2425 (comprising SEQ ID NOs: 52 and

53); DVD2426 (comprising SEQ ID NOs: 54 and 55); DVD2427 (comprising SEQ ID NOs: 56 and 57); DVD2428 (comprising SEQ ID NOs: 58 and 59); DVD2429 (comprising SEQ ID NOs: 60 and 61); DVD2430 (comprising SEQ ID NOs: 62 and 63); DVD2431 (comprising SEQ ID NOs: 64 and 65); DVD2432 (comprising SEQ ID NOs: 66 and 67); DVD2433 (comprising SEQ ID NOs: 68 and 69); DVD2434 (comprising SEQ ID NOs: 70 and 71); DVD2435 (comprising SEQ ID NOs: 72 and 73); DVD2436 (comprising SEQ ID NOs: 74 and 75); DVD2437 (comprising SEQ ID NOs: 76 and 77); DVD2438 (comprising SEQ ID NOs: 78 and 79); DVD2439 (comprising SEQ ID NOs: 80 and 81); DVD2440 (comprising SEQ ID NOs: 82 and 83); DVD2441 (comprising SEQ ID NOs: 84 and 85); DVD2442 (comprising SEQ ID NOs: 86 and 87); DVD3410 (comprising SEQ ID NOs: 88 and 89); DVD3411 (comprising SEQ ID NOs: 90 and 91); DVD3412 (comprising SEQ ID NOs: 92 and 93); DVD3413 (comprising SEQ ID NOs: 94 and 95); DVD3414 (comprising SEQ ID NOs: 96 and 97); DVD3415 (comprising SEQ ID NOs: 98 and 99); DVD3416 (comprising SEQ ID NOs: 100 and 101); DVD3417 (comprising SEQ ID NOs: 102 and 103); DVD3418 (comprising SEQ ID NOs: 104 and 105); DVD3419 (comprising SEQ ID NOs: 106 and 107); DVD3420 (comprising SEQ ID NOs: 108 and 109); DVD3421 (comprising SEQ ID NOs: 110 and 111); DVD3422 (comprising SEQ ID NOs: 112 and 113); DVD3423 (comprising SEQ ID NOs: 114 and 115); DVD3424 (comprising SEQ ID NOs: 116 and 117); and DVD3425 (comprising SEQ ID NOs: 118 and 119). In certain embodiments, the binding protein comprises any one of DVD2424, DVD2425, DVD2426, DVD2427, DVD2428, DVD2429, DVD2430, DVD3415, and DVD3418. In certain embodiments, the binding protein comprises DVD3415 or DVD3418. For further illustration of DVD-Ig binding protein structure and organization, see Table 2 below.

[041] In various embodiments, the binding proteins described above can comprise constant region amino acid sequences selected from wild type and mutated sequences. In some embodiments, a wild type human kappa light chain constant region sequence is used. In some embodiments, a wild type human lambda light chain constant region sequence is used. In some embodiments, wild type or mutant human IgG heavy chain constant region sequences are used. In some embodiments, wild type or mutant human IgG1 heavy chain constant region sequences are used. In certain embodiments, the mutated sequence is the one shown in Table 2a. In some embodiments, the binding proteins disclosed herein comprise a wild type human kappa light chain constant region sequence. In some embodiments, DVD2423-

DVD2442 comprise a wild type human kappa light chain constant region sequence and also comprise a wild type human heavy chain IgG1 constant region sequence. In some embodiments, DVD3410-DVD3425 comprise a wild type human kappa light chain constant region sequence and also comprise a mutant human heavy chain IgG1 constant region sequence (e.g., the sequence shown in Table 2b for DVD3418).

[042] In one embodiment, binding proteins comprising a polypeptide chain that binds IL-1 β and/or IL-17, wherein the polypeptide chain comprises VD1-(X1) n -VD2-C-X2, wherein VD1 is a first variable domain, VD2 is a second variable domain, C is a constant domain, X1 represents an amino acid or polypeptide, X2 represents an Fc region that is either present or absent, and n is 0 or 1, are provided. In an embodiment, the VD1 and/or VD2 in the binding protein are heavy chain variable domains. In an embodiment, the VD1 and/or VD2 in the binding protein are light chain variable domains. In another embodiment, VD1 and VD2 are capable of binding the same antigen. In another embodiment, VD1 and VD2 are capable of binding different antigens. In still another embodiment, C is a heavy chain constant domain. For example, X1 is a linker with the proviso that X1 is not CH1.

[043] In an embodiment, the binding protein disclosed herein comprises a polypeptide chain that binds IL-1 β and/or IL-17, wherein the polypeptide chain comprises VD1-(X1) n -VD2-C-X2, wherein VD1 is a first heavy chain variable domain, VD2 is a second heavy chain variable domain, C is a heavy chain constant domain, X1 is a linker, and X2 is an Fc region that is either present or absent. In an embodiment, X1 is a linker with the proviso that it is not CH1.

[044] In an embodiment, the binding protein disclosed herein comprises a polypeptide chain that binds IL-1 β and/or IL-17, wherein the polypeptide chain comprises VD1-(X1) n -VD2-C, wherein VD1 is a first light chain variable domain, VD2 is a second light chain variable domain, C is a light chain constant domain, X1 is a linker, and X2 is absent. In an embodiment, X1 is a linker with the proviso that it is not CL.

[045] In another embodiment, a binding protein that binds IL-1 β and/or IL-17 comprising two polypeptide chains, wherein the first polypeptide chain comprises VD1-(X1) n -VD2-C-X2, wherein VD1 is a first heavy chain variable domain, VD2 is a second heavy chain variable domain, C is a heavy chain constant domain, X1 is a first linker, and X2 is an Fc region; and the second polypeptide chain comprises VD1-(X1) n -VD2-C, wherein VD1 is a first light chain variable domain, VD2 is a second light

chain variable domain, C is a light chain constant domain, X1 is a second linker, and X2 is absent (i.e., there is no Fc on the second polypeptide chain). In some embodiments, the X1 on the first and second polypeptide chains are the same. In other embodiments, the X1 on the first and second polypeptide chains are different. In some embodiments the first X1 is not a CH1 domain and/or the second X1 is not a CL domain. In one embodiment, the first X1 and the second X1 are short (e.g., 6 amino acid) linkers. In another embodiment, the first X1 and the second X1 are long (e.g., greater than 6 amino acid) linkers. In another embodiment, the first X1 is a short linker and the second X1 is a long linker. In another embodiment, the first X1 is a long linker and the second X1 is a short linker.

[046] In an embodiment, the disclosure provides Dual Variable Domain (DVD) binding proteins comprising four polypeptide chains, wherein each of the first two polypeptide chains comprises VD1-(X1)_n-VD2-C-X2, wherein VD1 is a first heavy chain variable domain, VD2 is a second heavy chain variable domain, C is a heavy chain constant domain, X1 is a first linker, and X2 is an Fc region; and each of the second two polypeptide chain comprises VD1-(X1)_n-VD2-C, wherein VD1 is a first light chain variable domain, VD2 is a second light chain variable domain, C is a light chain constant domain, X1 is a second linker, and X2 is absent (i.e., there is no Fc on the second two polypeptide chains). Such a DVD-Ig binding protein has four antigen binding sites. In some embodiments, the first two polypeptide chains are identical, and the second two polypeptide chains are identical, with one of the first polypeptide chains paired with one of the second polypeptide chains, forming two target binding sites, on each arm of the DVD-Ig binding protein. In some embodiments, the X1 on the first and second polypeptide chains are the same. In other embodiments, the X1 on the first and second polypeptide chains are different. In some embodiments, the first X1 is not a complete CH1 domain and/or the second X1 is not a complete CL domain. In another embodiment, the binding proteins disclosed herein are capable of binding IL-1 β and IL-17. Accordingly, in some embodiments, the binding proteins comprise at least two variable domain sequences (e.g., VD1 and VD2) capable of binding IL-1 β and IL-17, in any orientation (i.e., capable of binding either IL-1 β or IL-17 at the VD1 position, and the same at the VD2 position). In some embodiments, VD1 and VD2 are independently chosen. Therefore, in some embodiments, VD1 and VD2 can comprise the same SEQ ID NO and, in other embodiments, VD1 and VD2 can comprise different SEQ ID NOS.

[047] In an embodiment, the disclosure provides a binding protein comprising first and second polypeptide chains, each independently comprising VD1-(X1) n -VD2-C-X2, wherein VD1 is a first variable domain; VD2 is a second variable domain; C is a constant domain; X1 is a linker with the proviso that it is not CH1; X2 is an Fc region that is present on one polypeptide chain and absent on the other chain; and n is 0 or 1, wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein the binding protein is capable of binding IL-1 β and IL-17, wherein (i) the variable domains that form a functional target binding site for IL-1 β comprise a sequence selected from the group consisting of SEQ ID NOs: 32-41 and/or the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, or at most about 3.4×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 2.563 nM, or at most about 2.067 nM, or at most about 1.568 nM, or at most about 0.424 nM, as measured in an IL-1 β neutralization assay, and/or (ii) the variable domains that form a functional target binding site for IL-17 comprise a sequence selected from the group consisting of SEQ ID NO: 42-47, and/or the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, or at most about 0.863 nM, or at most about 0.549 nM, as measured in an IL-17 neutralization assay.

[048] In an embodiment, a binding protein is provided comprising first and second polypeptide chains, each independently comprising VD1-(X1) n -VD2-C-X2, wherein VD1 is a first variable domain; VD2 is a second variable domain; C is a constant domain; X1 is a linker with the proviso that it is not CH1; X2 is an Fc region that is present on one polypeptide chain and absent on the other chain; and n is 0 or 1, wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein (a) the binding protein is capable of binding IL-1 β and IL-17, wherein (i) the variable domains that form a functional target binding site for IL-1 β comprise: CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33, CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35, CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3 from SEQ ID NO: 37, CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, or CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41; and/or the

binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, or at most about 3.4×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 2.563 nM, or at most about 2.067 nM, or at most about 1.568 nM, or at most about 0.424 nM, as measured in an IL-1 β neutralization assay, and/or (ii) the variable domains that form a functional target binding site for IL-17 comprise CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43; CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45; or CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47; and/or the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, or at most about 0.863 nM, or at most about 0.549 nM, as measured in an IL-17 neutralization assay.

[049] In an embodiment, a binding protein is provided, wherein the first polypeptide chain comprises a first VD1-(X1) n -VD2-C-X2, wherein VD1 is a first heavy chain variable domain; VD2 is a second heavy chain variable domain; C is a heavy chain constant domain; X1 is a linker with the proviso that it is not CH1; X2 is an Fc region; n is 0 or 1, and wherein the second polypeptide chain comprises a second VD1-(X1) n -VD2-C, wherein VD1 is a first light chain variable domain; VD2 is a second light chain variable domain; C is a light chain constant domain; X1 is a linker with the proviso that it is not CH1; n is 0 or 1; and the chain does not comprise an Fc region; and n is 0 or 1, wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site.

[050] In an embodiment, (a) the binding protein is capable of binding IL-1 β and IL-17, wherein (i) the variable domains that form a functional target binding site for IL-1 β comprise: (1) SEQ ID NO: 32 and SEQ ID NO: 33, (2) SEQ ID NO: 34 and SEQ ID NO: 35, (3) SEQ ID NO: 36 and SEQ ID NO: 37, (4) SEQ ID NO: 38 and SEQ ID NO: 39, or (5) SEQ ID NO: 40 and SEQ ID NO: 41; and/or (ii) the variable domains that form a functional target binding site for IL-17 comprise: (1) SEQ ID NO: 42 and SEQ ID NO: 43, (2) SEQ ID NO: 44 and SEQ ID NO: 45, or (3i) SEQ ID NO: 46 and SEQ ID NO: 47.

[051] In an embodiment, the binding protein comprises a first polypeptide chain comprising an outer variable domain of SEQ ID NO: 34, a linker between the outer and inner variable domains of SEQ ID NO: 29, and an inner variable domain of

SEQ ID NO: 44; and/or the binding protein comprises a second polypeptide chain comprising an outer variable domain of SEQ ID NO: 35, a linker between the outer and inner variable domains of SEQ ID NO: 30, and an inner variable domain of SEQ ID NO: 45. In an embodiment, the binding protein comprises a second polypeptide chain comprising an outer variable domain of SEQ ID NO: 34, a linker between the outer and inner variable domains of SEQ ID NO: 29, and an inner variable domain of SEQ ID NO: 44; and/or the binding protein comprises a first polypeptide chain comprising an outer variable domain of SEQ ID NO: 35, a linker between the outer and inner variable domains of SEQ ID NO: 30, and an inner variable domain of SEQ ID NO: 45. In certain embodiments, the binding protein comprises a first polypeptide chain comprising SEQ ID NO: 104 and a second polypeptide chain comprising SEQ ID NO: 105.

[052] In an embodiment, the binding protein comprises a first polypeptide chain comprising an outer variable domain of SEQ ID NO: 32, a linker between the outer and inner variable domains of SEQ ID NO: 29, and an inner variable domain of SEQ ID NO: 44; and/or the binding protein comprises a second polypeptide chain comprising an outer variable domain of SEQ ID NO: 33, a linker between the outer and inner variable domains of SEQ ID NO: 30, and an inner variable domain of SEQ ID NO: 45. In an embodiment, the binding protein comprises a second polypeptide chain comprising an outer variable domain of SEQ ID NO: 32, a linker between the outer and inner variable domains of SEQ ID NO: 29, and an inner variable domain of SEQ ID NO: 44; and/or the binding protein comprises a first polypeptide chain comprising an outer variable domain of SEQ ID NO: 33, a linker between the outer and inner variable domains of SEQ ID NO: 30, and an inner variable domain of SEQ ID NO: 45. In certain embodiments, the binding protein comprises a first polypeptide chain comprising SEQ ID NO: 98 and a second polypeptide chain comprising SEQ ID NO: 99.

[053] In an embodiment, the binding protein comprises two first polypeptide chains and two second polypeptide chains, wherein the binding protein comprises four functional target binding sites.

[054] In an embodiment, the disclosure provides a binding protein capable of binding IL-1 β and IL-17, wherein the binding protein comprises any one of: DVD2423 (comprising first and second polypeptide chains of SEQ ID NOs: 48 and 49); DVD2424 (comprising SEQ ID NOs: 50 and 51); DVD2425 (comprising SEQ ID NOs: 52 and 53); DVD2426 (comprising SEQ ID NOs: 54 and 55); DVD2427

(comprising SEQ ID NOs: 56 and 57); DVD2428 (comprising SEQ ID NOs: 58 and 59); DVD2429 (comprising SEQ ID NOs: 60 and 61); DVD2430 (comprising SEQ ID NOs: 62 and 63); DVD2431 (comprising SEQ ID NOs: 64 and 65); DVD2432 (comprising SEQ ID NOs: 66 and 67); DVD2433 (comprising SEQ ID NOs: 68 and 69); DVD2434 (comprising SEQ ID NOs: 70 and 71); DVD2435 (comprising SEQ ID NOs: 72 and 73); DVD2436 (comprising SEQ ID NOs: 74 and 75); DVD2437 (comprising SEQ ID NOs: 76 and 77); DVD2438 (comprising SEQ ID NOs: 78 and 79); DVD2439 (comprising SEQ ID NOs: 80 and 81); DVD2440 (comprising SEQ ID NOs: 82 and 83); DVD2441 (comprising SEQ ID NOs: 84 and 85); DVD2442 (comprising SEQ ID NOs: 86 and 87); DVD3410 (comprising SEQ ID NOs: 88 and 89); DVD3411 (comprising SEQ ID NOs: 90 and 91); DVD3412 (comprising SEQ ID NOs: 92 and 93); DVD3413 (comprising SEQ ID NOs: 94 and 95); DVD3414 (comprising SEQ ID NOs: 96 and 97); DVD3415 (comprising SEQ ID NOs: 98 and 99); DVD3416 (comprising SEQ ID NOs: 100 and 101); DVD3417 (comprising SEQ ID NOs: 102 and 103); DVD3418 (comprising SEQ ID NOs: 104 and 105); DVD3419 (comprising SEQ ID NOs: 106 and 107); DVD3420 (comprising SEQ ID NOs: 108 and 109); DVD3421 (comprising SEQ ID NOs: 110 and 111); DVD3422 (comprising SEQ ID NOs: 112 and 113); DVD3423 (comprising SEQ ID NOs: 114 and 115); DVD3424 (comprising SEQ ID NOs: 116 and 117); and DVD3425 (comprising SEQ ID NOs: 118 and 119). In an embodiment, the binding protein is DVD3415 (comprising first and second polypeptide chains of SEQ ID NOs: 98 and 99) or DVD3418 (comprising first and second polypeptide chains of SEQ ID NOs: 104 and 105).

[055] In another embodiment, the binding protein comprises a paired heavy chain and a light chain sequence as shown in Table 1 herein, forming a functional binding site from the paired heavy and light chains.

[056] Any of the heavy chain, light chain, two chain, or four chain embodiments can include at least one X1 linker comprising AKTTPKLEEGEFSEAR (SEQ ID NO: 1); AKTTPKLEEGEFSEARV (SEQ ID NO: 2); AKTTPKLGG (SEQ ID NO: 3); SAKTTPKLGG (SEQ ID NO: 4); SAKTTP (SEQ ID NO: 5); RADAAP (SEQ ID NO: 6); RADAAPTVS (SEQ ID NO: 7); RADAAAAGGPGS (SEQ ID NO: 8); RADAAAA(G₄S)₄ (SEQ ID NO: 9); SAKTTPKLEEGEFSEARV (SEQ ID NO: 10); ADAAP (SEQ ID NO: 11); ADAAPTVSIFPP (SEQ ID NO: 12); TVAAP (SEQ ID NO: 13); TVAAPSVFIFPP (SEQ ID NO: 14); QPKAAP (SEQ ID NO: 15); QPKAAPSVTLFPP (SEQ ID NO: 16); AKTTPP (SEQ ID NO: 17); AKTTPPSVTPLAP (SEQ ID NO: 18); AKTTAP (SEQ ID NO: 19); AKTTAPSVYPLAP (SEQ ID NO: 20);

ASTKGP (SEQ ID NO: 21); ASTKGPSVFPLAP (SEQ ID NO: 22),
 GGGGSGGGGSGGGGS (SEQ ID NO: 23); GENKVEYAPALMALS (SEQ ID NO: 24);
 GPAKELTPLKEAKVS (SEQ ID NO: 25); or GHEAAVMQVQYPAS (SEQ ID NO: 26);
 TVAAPSVFIFPPTVAAPSVFIFPP (SEQ ID NO: 27);
 ASTKGPSVFPLAPASTKGPSVFPLAP (SEQ ID NO: 28); GGGGSGGGGGS (SEQ ID
 NO: 29); GGSGGGGSG (SEQ ID NO: 30); or G/S based sequences (e.g., G4S and
 G4S repeats; SEQ ID NO: 31). In an embodiment, X1 is not a constant region, is not
 a CH region, and/or is not a CL region. In an embodiment, the linker is
 GGGGSGGGGGS (SEQ ID NO: 29) on the first chain and/or GGSGGGGSG (SEQ ID
 NO: 30) on the second chain. In an embodiment, the linker is GGSGGGGSG (SEQ
 ID NO: 30) on the first chain and/or GGGGSGGGGGS (SEQ ID NO: 29) on the second
 chain.

[057] In an embodiment, X2 is an Fc region. In another embodiment, the Fc
 region is a variant Fc region. In still another embodiment, the Fc region, if present, is
 a native sequence Fc region or a variant sequence Fc region. In yet another
 embodiment, the Fc region is an Fc region from an IgG1, an Fc region from an IgG2,
 an Fc region from an IgG3, an Fc region from an IgG4, an Fc region from an IgA, an
 Fc region from an IgM, an Fc region from an IgE, or an Fc region from an IgD.

Binding Protein Properties

[058] The development and production of a binding protein for use as a
 human therapeutic agent, e.g., as an anti-inflammatory agent or neurological agent,
 may require more than the identification of a binding protein capable of binding to a
 desired target or targets. The binding proteins disclosed herein exhibit favorable
 properties in one or more of the following categories (a) the binding kinetics (on-rate,
 off-rate and affinity) for both the inner and outer antigen-binding domains, (b)
 potencies in various biochemical and cellular bioassays, (c) in vivo efficacies in
 relevant tumor models, (d) pharmacokinetic and pharmacodynamics properties, (e)
 manufacturability, including protein expression level in selected cell lines, scalability,
 post-translational modification, physicochemical properties such as monomer
 percentage, solubility, and stability (intrinsic, freeze/thaw, storage stability, etc.), (f)
 formulation properties, (g) potential immunogenicity risk, (h) toxicological properties,
 and (i) binding mode and valency. Binding mode and valency may affect binding
 properties and cellular potencies of a molecule.

[059] The binding proteins disclosed herein exhibit favorable properties in some or each of the categories listed above, including surprisingly high binding affinity at both the VD1 and VD2 positions. In certain embodiments, a binding protein exhibiting particularly favorable properties in some or each of the categories listed above contains first and second polypeptide chains that comprise SEQ ID NO: 104 and SEQ ID NO: 105 or first and second polypeptide chains that comprise SEQ ID NO: 98 and SEQ ID NO: 99. In certain embodiments, the binding protein comprises DVD3415 or DVD3418. These binding proteins have been found to exhibit a surprisingly high binding affinity at both the VD1 and VD2 positions. See, e.g., Table 10. It has also been found, unexpectedly, that DVD3415 and DVD3418 may, in some embodiments, exhibit a superior combination of one or more properties, such as one or more of: effective binding kinetics, improved neutralization ability, enhanced in vivo efficacy, superior formulatability, a desirable glycosylation pattern, a favorable pharmacokinetic profile, and efficient expression in host cells, as compared to other binding proteins comprising different variable domains and/or linker sequences.

[060] For instance, it has unexpectedly been found that many of the binding proteins disclosed herein bind their targets with an affinity roughly comparable (i.e., within the same order of magnitude) to that of both their individual parent antibodies. See, for example, the comparison of parental antibodies and binding proteins in Tables 3-6. This is surprising as loss in binding affinity may have been anticipated a priori from the use of a dual variable domain binding structure. In particular, it has been found that binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418) exhibit superior binding affinity to both their targets, as compared to other binding proteins comprising different variable domains targeting IL-1 β and IL-17, and/or different linker sequences. For instance, binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418) bound with surprisingly high affinity to both IL-1 β and IL-17 (e.g., an affinity comparable to that of their parent antibodies), whereas other binding proteins using different variable domain sequences bound with less affinity than their parent antibodies. See, e.g., Table 6. Moreover, it has surprisingly been found that binding proteins such as DVD3415 and DVD3418 exhibit physicochemical properties that, in combination, are superior to those of other binding proteins. For instance, binding proteins DVD3415 and DVD3418, which are engineered to lack a deamidation site in their IL-17 binding domain, surprisingly exhibit a combination of properties that are superior to those of

other binding proteins disclosed herein, or as compared to other DVD-Ig binding proteins targeting IL-1 β and IL-17, such as DVD1274, DVD1275, DVD1601, DVD1602, DVD1631, DVD1661, and DVD1662. See, e.g., Table 13. These beneficial properties include superior host cell expression, retained target potency for both IL-1 β and IL-17, improved solubility, improved stability and formulatability, reduced cross-reactivity to other antigens or to IL-1 β and IL-17 from non-primate species, improved in vivo efficacy, and reduced immunogenicity (including reduced immunogenicity as compared to dual administration of anti-IL-1 β and anti-IL-17 antibodies, and as compared to alternate binding proteins such as a binding protein targeting IL-17 and TNF). Both binding proteins are surprisingly stable at a high concentration (e.g., greater than 25 mg/ml liquid formulation). Both binding proteins are also selective for primate IL-1 β and IL-17 over antigens from other species, and exhibit neutralizing properties against primate IL-1 β and IL-17. See, e.g., Table 14.

[061] In some embodiments, binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418) are capable of being concentrated, e.g., to greater than 25 mg/ml, and/or can be concentrated to a similar level as their parental antibodies. In some embodiments, binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418) exhibit a prolonged half-life, at least a moderate plasma clearance, and/or significant homology to germline sequences (which may contribute to reduced immunogenicity), as compared to those of other binding proteins disclosed herein, or as compared to other DVD-Ig binding proteins targeting IL-1 β and IL-17, such as DVD1274, DVD1275, DVD1601, DVD1602, DVD1631, DVD1661. See, e.g., Tables 11 and 13. For instance, DVD3415 and/or DVD3418 may exhibit a serum half-life of approximately 20-40 days (e.g., 20, 25, 30, 35, or 40 days, or any time period in between). In some embodiments, DVD3415 and/or DVD3418 exhibit a lower clearance rate than is observed for other DVD-Ig binding proteins targeting IL-1 β and IL-17, e.g., a rate of less than 0.1 ml/hour/kg body mass, or less than 0.09, 0.08, 0.07, 0.06, 0.05 ml/hour/kg body mass (or any rate in between).

[062] In some embodiments, binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418), exhibit surprisingly favorable physicochemical characteristics, including solubility, viscosity, stability on freeze thaw, and/or lack of other significant changes during thermal stress, as compared to other binding proteins disclosed herein and/or

as compared to other binding proteins targeting IL-1 β and IL-17. As such, DVD3415 and/or DVD3418 may be suitable for formulation in a stable high concentration liquid formulation, e.g., a concentration greater than 15, 20, 25, 30, 35, 40, 45, or 50 mg/ml in a liquid formulation (or any concentration in between). See, e.g., Table 12. In some embodiments, DVD3415 and/or DVD3418 exhibit reduced immunogenicity in vivo, as compared to dual administration of anti-IL-1 β and anti-IL-17 antibodies, and/or as compared to alternate binding proteins such as a binding protein targeting IL-17 and TNF.

[063] In various embodiments, binding proteins comprising SEQ ID NO: 104 and SEQ ID NO: 105 or SEQ ID NO: 98 and SEQ ID NO: 99 (e.g., DVD3415 and DVD3418) exhibit improved properties, e.g., improved safety, increased stability, greater potency, a reduced inflammatory or immune response, or other beneficial in vivo human therapeutic properties, as compared to other treatments for inflammatory, autoimmune, or neurological conditions. Treatments suitable for comparison can include, e.g., administration of a small molecule anti-inflammatory or neurological agent, or administration of an antibody against IL-1 β alone or in combination with an antibody against IL-17, or administration of a DVD-Ig binding protein comprising other variable domain sequences and forming binding sites for IL-1 β and IL-17. In some embodiments, DVD3415 and/or 3418 exhibits improved properties over a current standard of care treatment for an autoimmune, inflammatory, or neurological condition. For instance, the binding protein can exhibit improved binding kinetics, superior in vivo therapeutic efficacy, enhanced formulatability (including reduced aggregation and improved storage stability), improved pharmacokinetics, a reduced inflammatory or immune response, and/or enhanced host cell expression levels.

Preparation of Binding Proteins

[064] In another aspect, the disclosure provides a method of making a binding protein that binds IL-1 β and/or IL-17 is provided. In an embodiment, the method of making a binding protein that binds IL-1 β and/or IL-17 comprises the steps of a) obtaining a first parent antibody, or antigen binding portion thereof, that binds IL-1 β and/or IL-17; b) obtaining a second parent antibody, or antigen binding portion thereof, that binds IL-1 β and/or IL-17; c) determining the sequences of the variable domains of the parent antibodies or antigen binding portions thereof; d) preparing construct(s) encoding any of the binding proteins described herein using those

variable domain sequences; and e) expressing the polypeptide chains, such that a binding protein that binds IL-1 β and/or IL-17 is generated.

[065] In any of the embodiments herein, the VD1 heavy chain variable domain, if present, and light chain variable domain, if present, can be from a first parent antibody or antigen binding portion thereof; the VD2 heavy chain variable domain, if present, and light chain variable domain, if present, can be from a second parent antibody or antigen binding portion thereof. The first and second parent antibodies can be the same or different.

[066] In one embodiment, the first parent antibody or antigen binding portion thereof, binds a first antigen, and the second parent antibody or antigen binding portion thereof, binds a second antigen. In an embodiment, the first and second antigens are the same antigen. In another embodiment, the parent antibodies bind different epitopes on the same antigen. In another embodiment, the first and second antigens are different antigens. In another embodiment, the first parent antibody or antigen binding portion thereof, binds the first antigen with a potency different from the potency with which the second parent antibody or antigen binding portion thereof, binds the second antigen. In yet another embodiment, the first parent antibody or antigen binding portion thereof, binds the first antigen with an affinity different from the affinity with which the second parent antibody or antigen binding portion thereof, binds the second antigen.

[067] In another embodiment, the first parent antibody or antigen binding portion thereof, and the second parent antibody or antigen binding portion thereof, are a human antibody, CDR grafted antibody, humanized antibody, and/or affinity matured antibody.

[068] In another embodiment, the binding protein possesses at least one desired property exhibited by the first parent antibody or antigen binding portion thereof, or the second parent antibody or antigen binding portion thereof. Alternatively, the first parent antibody or antigen binding portion thereof and the second parent antibody or antigen binding portion thereof possess at least one desired property exhibited by the binding protein. In an embodiment, the desired property is one or more antibody parameters. In another embodiment, the antibody parameters are antigen specificity, affinity to antigen, potency, biological function, epitope recognition, stability, solubility, production efficiency, immunogenicity, pharmacokinetics, bioavailability, tissue cross reactivity, or orthologous antigen

binding. In an embodiment, the binding protein is multivalent. In another embodiment, the binding protein is multispecific. The multivalent and or multispecific binding proteins described herein have desirable properties particularly from a therapeutic standpoint. For instance, the multivalent and or multispecific binding protein may (1) be internalized (and/or catabolized) faster than a bivalent antibody by a cell expressing an antigen to which the antibodies bind; (2) be an agonist binding protein; and/or (3) induce cell death and/or apoptosis of a cell expressing an antigen to which the multivalent binding protein is capable of binding. The "parent antibody", which provides at least one antigen binding specificity of the multivalent and or multispecific binding protein, may be one that is internalized (and/or catabolized) by a cell expressing an antigen to which the antibody binds; and/or may be an agonist, cell death-inducing, and/or apoptosis-inducing antibody, and the multivalent and or multispecific binding protein as described herein may display improvement(s) in one or more of these properties. Moreover, the parent antibody may lack any one or more of these properties, but may acquire one or more of them when constructed as a multivalent binding protein as described herein. For example, different Fc mutants may prevent FcR, C' binding, or extend half-life.

[069] In another embodiment, the binding protein has an on rate constant (K_{on}) to one or more targets of at least about $10^2 M^{-1} s^{-1}$; at least about $10^3 M^{-1} s^{-1}$; at least about $10^4 M^{-1} s^{-1}$; at least about $10^5 M^{-1} s^{-1}$; or at least about $10^6 M^{-1} s^{-1}$, as measured by surface plasmon resonance. In an embodiment, the binding protein has an on rate constant (K_{on}) to one or more targets from about $10^2 M^{-1} s^{-1}$ to about $10^3 M^{-1} s^{-1}$; from about $10^3 M^{-1} s^{-1}$ to about $10^4 M^{-1} s^{-1}$; from about $10^4 M^{-1} s^{-1}$ to about $10^5 M^{-1} s^{-1}$; or from about $10^5 M^{-1} s^{-1}$ to about $10^6 M^{-1} s^{-1}$, as measured by surface plasmon resonance.

[070] In another embodiment, the binding protein has an off rate constant (K_{off}) for one or more targets of at most about $10^{-3} s^{-1}$; at most about $10^{-4} s^{-1}$; at most about $10^{-5} s^{-1}$; or at most about $10^{-6} s^{-1}$, as measured by surface plasmon resonance. In an embodiment, the binding protein has an off rate constant (K_{off}) to one or more targets of about $10^{-3} s^{-1}$ to about $10^{-4} s^{-1}$; of about $10^{-4} s^{-1}$ to about $10^{-5} s^{-1}$; or of about $10^{-5} s^{-1}$ to about $10^{-6} s^{-1}$, as measured by surface plasmon resonance.

[071] In another embodiment, the binding protein has a dissociation constant (K_d) to one or more targets of at most about $10^{-7} M$; at most about $10^{-8} M$; at most about $10^{-9} M$; at most about $10^{-10} M$; at most about $10^{-11} M$; at most about $10^{-12} M$; or at most $10^{-13} M$. In an embodiment, the binding protein has a dissociation constant (K_d) to its targets of about $10^{-7} M$ to about $10^{-8} M$; of about $10^{-8} M$ to about $10^{-9} M$; of

about 10^{-9} M to about 10^{-10} M; of about 10^{-10} M to about 10^{-11} M; of about 10^{-11} M to about 10^{-12} M; or of about 10^{-12} to M about 10^{-13} M.

[072] In another embodiment, the binding protein is a conjugate further comprising an agent. In an embodiment, the agent is an immunoadhesion molecule, an imaging agent, a therapeutic agent, or a cytotoxic agent. In an embodiment, the imaging agent is a radiolabel, an enzyme, a fluorescent label, a luminescent label, a bioluminescent label, a magnetic label, or biotin. In another embodiment, the radiolabel is ^3H , ^{14}C , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I , ^{177}Lu , ^{166}Ho , or ^{153}Sm . In yet another embodiment, the therapeutic or cytotoxic agent is an anti-metabolite, an alkylating agent, an antibiotic, a growth factor, a cytokine, an anti-angiogenic agent, an anti-mitotic agent, an anthracycline, toxin, or an apoptotic agent, or an immunosuppressive agent.

[073] In another embodiment, the binding protein is a crystallized binding protein and exists as a crystal. In an embodiment, the crystal is a carrier-free pharmaceutical controlled release crystal. In another embodiment, the crystallized binding protein has a greater half life in vivo than the soluble counterpart of the binding protein. In yet another embodiment, the crystallized binding protein retains biological activity.

[074] In another embodiment, the binding protein described herein is glycosylated. For example, the glycosylation pattern is a human glycosylation pattern.

[075] An isolated nucleic acid encoding any one of the binding proteins disclosed herein is also provided. A further embodiment provides a vector comprising the isolated nucleic acid disclosed herein wherein the vector is pcDNA; pTT (Durocher et al. (2002) Nucleic Acids Res. 30(2); pTT3 (pTT with additional multiple cloning site; pEFBOS (Mizushima and Nagata (1990) Nucleic Acids Res. 18(17); pBV; pJV; pcDNA3.1 TOPO; pEF6 TOPO; pBOS; pHybE; or pBJ. In an embodiment, the vector is a vector disclosed in US Patent Publication No. 20090239259.

[076] In another aspect, a host cell is transformed with the vector disclosed herein. In an embodiment, the host cell is a prokaryotic cell, for example, E.coli. In another embodiment, the host cell is a eukaryotic cell, for example, a protist cell, an animal cell, a plant cell, or a fungal cell. In an embodiment, the host cell is a mammalian cell including, but not limited to, CHO, COS, NS0, SP2, PER.C6, or a fungal cell, such as *Saccharomyces cerevisiae*, or an insect cell, such as Sf9. In an embodiment, two or more binding proteins, e.g., with different specificities, are

produced in a single recombinant host cell. For example, the expression of a mixture of antibodies has been called Oligoclonics™ (Merus B.V., The Netherlands) US Patent Nos. 7,262,028 and 7,429,486.

[077] A method of producing a binding protein is disclosed herein, comprising culturing any one of the host cells disclosed herein in a culture medium under conditions sufficient to produce the binding protein. In an embodiment, 50%-75% of the binding protein produced by this method is a dual specific tetravalent binding protein (e.g., a DVD-Ig binding protein). In another embodiment, 75%-90% of the binding protein produced by this method is a dual specific tetravalent binding protein. In another embodiment, 90%-95% of the binding protein produced is a dual specific tetravalent binding protein.

[078] One embodiment provides a composition for the release of a binding protein wherein the composition comprises a crystallized binding protein, an ingredient, and at least one polymeric carrier. In an embodiment, the polymeric carrier is poly (acrylic acid), a poly (cyanoacrylate), a poly (amino acid), a poly (anhydride), a poly (depsipeptide), a poly (ester), poly (lactic acid), poly (lactic-co-glycolic acid) or PLGA, poly (b-hydroxybutyrate), poly (caprolactone), poly (dioxanone), poly (ethylene glycol), poly ((hydroxypropyl) methacrylamide, poly [(organo)phosphazene], a poly (ortho ester), poly (vinyl alcohol), poly (vinylpyrrolidone), a maleic anhydride- alkyl vinyl ether copolymer, a pluronic polyol, albumin, alginate, cellulose, a cellulose derivative, collagen, fibrin, gelatin, hyaluronic acid, an oligosaccharide, a glycaminoglycan, a sulfated polysaccharide, or blends and copolymers thereof. In an embodiment, the ingredient is albumin, sucrose, trehalose, lactitol, gelatin, hydroxypropyl- β - cyclodextrin, methoxypolyethylene glycol, or polyethylene glycol.

[079] Another embodiment provides a method for treating a mammal comprising the step of administering to the mammal an effective amount of a composition disclosed herein.

[080] A pharmaceutical composition comprising a binding protein disclosed herein and a pharmaceutically acceptable carrier is provided. In a further embodiment, the pharmaceutical composition comprises at least one additional therapeutic agent for treating a disorder. For example, the additional agent may be a therapeutic agent, an imaging agent, a cytotoxic agent, an angiogenesis inhibitor (including but not limited to an anti-VEGF antibody or a VEGF-trap), a kinase inhibitor (including but not limited to a KDR and a TIE-2 inhibitor), a co-stimulation molecule blocker (including

but not limited to anti-B7.1, anti-B7.2, CTLA4-Ig, anti-CD20), an adhesion molecule blocker (including but not limited to an anti-LFA-1 antibody, an anti-E/L selectin antibody, a small molecule inhibitor), an anti-cytokine antibody or functional fragment thereof (including but not limited to an anti-IL-18, an anti-TNF, and an anti-IL-6/cytokine receptor antibody), methotrexate, cyclosporin, rapamycin, FK506, a detectable label or reporter, a TNF antagonist, an antirheumatic, a muscle relaxant, a narcotic, a non-steroid anti-inflammatory drug (NSAID), an analgesic, an anesthetic, a sedative, a local anesthetic, a neuromuscular blocker, an antimicrobial, an antipsoriatic, a corticosteroid, an anabolic steroid, an erythropoietin, an immunization, an immunoglobulin, an immunosuppressive, a growth hormone, a hormone replacement drug, a radiopharmaceutical, an antidepressant, an antipsychotic, a stimulant, an asthma medication, a beta agonist, an inhaled steroid, an epinephrine or analog, a cytokine, or a cytokine antagonist.

Therapeutic and Diagnostic Uses

[081] A method for treating a human subject suffering from a disorder in which the target, or targets, capable of being bound by the binding protein disclosed herein is detrimental, comprising administering to the human subject a binding protein disclosed herein such that the activity of the target, or targets, in the human subject is inhibited and one or more symptoms is alleviated or treatment is achieved is provided. The binding proteins provided herein can be used to treat humans suffering from autoimmune diseases such as, for example, those associated with inflammation. In an embodiment, the binding proteins provided herein or antigen-binding portions thereof, are used to treat asthma, allergies, allergic lung disease, allergic rhinitis, atopic dermatitis, inflammatory pustular skin disease, Behcet's disease, Systemic Juvenile Idiopathic Arthritis, Familial Mediterranean Fever, Neonatal Onset Multisystem Inflammatory disease, acute heart failure, post-infarction remodeling, pulmonary hypertension, type 1 diabetes, proliferative Diabetic Retinopathy, Congenital Hyperinsulinism, Schnitzler Syndrome, gout flares, pyoderma gangrenosum, chronic obstructive pulmonary disease (COPD), fibrosis, cystic fibrosis (CF), fibrotic lung disease, idiopathic pulmonary fibrosis, liver fibrosis, lupus, hepatitis B-related liver diseases and fibrosis, sepsis, systemic lupus erythematosus (SLE), glomerulonephritis, inflammatory skin diseases, psoriasis, diabetes, insulin dependent diabetes mellitus, infectious diseases caused by HIV, inflammatory bowel disease (IBD), ulcerative colitis (UC), Crohn's disease (CD), rheumatoid arthritis (RA), osteoarthritis (OA), multiple sclerosis (MS), graft-versus-host disease (GVHD),

transplant rejection, ischemic heart disease (IHD), celiac disease, contact hypersensitivity, alcoholic liver disease, Behcet's disease, atherosclerotic vascular disease, ocular surface inflammatory diseases, or Lyme disease.

[082] In another embodiment, the disorder or condition to be treated comprises the symptoms caused by viral infection in a human which is caused by, for example, HIV, the human rhinovirus, an enterovirus, a coronavirus, a herpes virus, an influenza virus, a parainfluenza virus, a respiratory syncytial virus or an adenovirus.

[083] The binding proteins provided herein can be used to treat neurological disorders. In an embodiment, the binding proteins provided herein, or antigen-binding portions thereof, are used to treat neurodegenerative diseases and conditions involving neuronal regeneration and spinal cord injury.

[084] In an embodiment, diseases that can be treated or diagnosed with the compositions and methods disclosed herein include, but are not limited to, primary and metastatic cancers, including carcinomas of breast, colon, rectum, lung, oropharynx, hypopharynx, esophagus, stomach, pancreas, liver, gallbladder and bile ducts, small intestine, urinary tract (including kidney, bladder and urothelium), female genital tract (including cervix, uterus, and ovaries as well as choriocarcinoma and gestational trophoblastic disease), male genital tract (including prostate, seminal vesicles, testes and germ cell tumors), endocrine glands (including the thyroid, adrenal, and pituitary glands), and skin, as well as hemangiomas, melanomas, sarcomas (including those arising from bone and soft tissues as well as Kaposi's sarcoma), tumors of the brain, nerves, eyes, and meninges (including astrocytomas, gliomas, glioblastomas, retinoblastomas, neuromas, neuroblastomas, Schwannomas, and meningiomas), solid tumors arising from hematopoietic malignancies such as leukemias, and lymphomas (both Hodgkin's and non-Hodgkin's lymphomas).

[085] Another embodiment provides for the use of the binding protein in the treatment of a disease or disorder, wherein the disease or disorder is rheumatoid arthritis, osteoarthritis, juvenile chronic arthritis, septic arthritis, Lyme arthritis, psoriatic arthritis, reactive arthritis, spondyloarthropathy, systemic lupus erythematosus, Crohn's disease, ulcerative colitis, inflammatory bowel disease, insulin dependent diabetes mellitus, thyroiditis, asthma, allergic diseases, psoriasis, dermatitis scleroderma, graft versus host disease, organ transplant rejection, acute or chronic immune disease associated with organ transplantation, sarcoidosis, atherosclerosis, disseminated intravascular coagulation, Kawasaki's disease, Grave's

disease, nephrotic syndrome, chronic fatigue syndrome, Wegener's granulomatosis, Henoch-Schoenlein purpura, microscopic vasculitis of the kidneys, chronic active hepatitis, uveitis, septic shock, toxic shock syndrome, sepsis syndrome, cachexia, infectious diseases, parasitic diseases, acquired immunodeficiency syndrome, acute transverse myelitis, Huntington's chorea, Parkinson's disease, Alzheimer's disease, stroke, primary biliary cirrhosis, hemolytic anemia, malignancies, heart failure, Addison's disease, sporadic, polyglandular deficiency type I and polyglandular deficiency type II, Schmidt's syndrome, adult (acute) respiratory distress syndrome, alopecia, alopecia areata, arthropathy, Reiter's disease, psoriatic arthropathy, ulcerative colitic arthropathy, enteropathic synovitis, chlamydia, yersinia and salmonella associated arthropathy, atheromatous disease/arteriosclerosis, atopic allergy, autoimmune bullous disease, pemphigus vulgaris, pemphigus foliaceus, pemphigoid, linear IgA disease, autoimmune haemolytic anaemia, Coombs positive haemolytic anaemia, acquired pernicious anaemia, juvenile pernicious anaemia, myalgic encephalitis/Royal Free Disease, chronic mucocutaneous candidiasis, giant cell arteritis, primary sclerosing hepatitis, cryptogenic autoimmune hepatitis, acquired immunodeficiency related diseases, hepatitis B, hepatitis C, common varied immunodeficiency (common variable hypogammaglobulinaemia), dilated cardiomyopathy, female infertility, ovarian failure, premature ovarian failure, fibrotic lung disease, cryptogenic fibrosing alveolitis, post-inflammatory interstitial lung disease, interstitial pneumonitis, connective tissue disease associated interstitial lung disease, mixed connective tissue disease associated lung disease, systemic sclerosis associated interstitial lung disease, rheumatoid arthritis associated interstitial lung disease, systemic lupus erythematosus associated lung disease, dermatomyositis/polymyositis associated lung disease, Sjögren's disease associated lung disease, ankylosing spondylitis associated lung disease, vasculitic diffuse lung disease, haemosiderosis associated lung disease, drug-induced interstitial lung disease, fibrosis, radiation fibrosis, bronchiolitis obliterans, chronic eosinophilic pneumonia, lymphocytic infiltrative lung disease, postinfectious interstitial lung disease, gouty arthritis, autoimmune hepatitis, type-1 autoimmune hepatitis (classical autoimmune or lupoid hepatitis), type-2 autoimmune hepatitis (anti-LKM antibody hepatitis), autoimmune mediated hypoglycaemia, type B insulin resistance with acanthosis nigricans, hypoparathyroidism, acute immune disease associated with organ transplantation, chronic immune disease associated with organ transplantation, osteoarthritis, primary sclerosing cholangitis, psoriasis type 1, psoriasis type 2, idiopathic leucopaenia, autoimmune neutropaenia, renal disease NOS,

glomerulonephritides, microscopic vasculitis of the kidneys, lyme disease, discoid lupus erythematosus, male infertility idiopathic or NOS, sperm autoimmunity, multiple sclerosis (all subtypes), sympathetic ophthalmia, pulmonary hypertension secondary to connective tissue disease, Goodpasture's syndrome, pulmonary manifestation of polyarteritis nodosa, acute rheumatic fever, rheumatoid spondylitis, Still's disease, systemic sclerosis, Sjögren's syndrome, Takayasu's disease/arteritis, autoimmune thrombocytopaenia, idiopathic thrombocytopaenia, autoimmune thyroid disease, hyperthyroidism, goitrous autoimmune hypothyroidism (Hashimoto's disease), atrophic autoimmune hypothyroidism, primary myxoedema, phacogenic uveitis, primary vasculitis, vitiligo acute liver disease, chronic liver diseases, alcoholic cirrhosis, alcohol-induced liver injury, choleosatatis, idiosyncratic liver disease, drug-induced hepatitis, non-alcoholic steatohepatitis, allergy and asthma, group B streptococci (GBS) infection, mental disorders, depression, schizophrenia, Th2 Type and Th1 Type mediated diseases, acute and chronic pain, different forms of pain, cancers, lung cancer, breast cancer, stomach cancer, bladder cancer, colon cancer, pancreatic cancer, ovarian cancer, prostate cancer, rectal cancer, hematopoietic malignancies, leukemia, lymphoma, Abetalipoproteinemia, acrocyanosis, acute and chronic parasitic or infectious processes, acute leukemia, acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), acute or chronic bacterial infection, acute pancreatitis, acute renal failure, adenocarcinomas, aerial ectopic beats, AIDS dementia complex, alcohol-induced hepatitis, allergic conjunctivitis, allergic contact dermatitis, allergic rhinitis, allograft rejection, alpha-1-antitrypsin deficiency, amyotrophic lateral sclerosis, anemia, angina pectoris, anterior horn cell degeneration, anti cd3 therapy, antiphospholipid syndrome, anti-receptor hypersensitivity reactions, aortic and peripheral aneurysms, aortic dissection, arterial hypertension, arteriosclerosis, arteriovenous fistula, ataxia, atrial fibrillation (sustained or paroxysmal), atrial flutter, atrioventricular block, B cell lymphoma, bone graft rejection, bone marrow transplant (BMT) rejection, bundle branch block, Burkitt's lymphoma, burns, cardiac arrhythmias, cardiac stun syndrome, cardiac tumors, cardiomyopathy, cardiopulmonary bypass inflammation response, cartilage transplant rejection, cerebellar cortical degenerations, cerebellar disorders, chaotic or multifocal atrial tachycardia, chemotherapy associated disorders, chronic myelocytic leukemia (CML), chronic alcoholism, chronic inflammatory pathologies, chronic lymphocytic leukemia (CLL), chronic obstructive pulmonary disease (COPD), chronic salicylate intoxication, colorectal carcinoma, congestive heart failure, conjunctivitis, contact dermatitis, cor pulmonale, coronary artery disease, Creutzfeldt-Jakob disease, culture

negative sepsis, cystic fibrosis, cytokine therapy associated disorders, dementia pugilistica, demyelinating diseases, dengue hemorrhagic fever, dermatitis, dermatologic conditions, diabetes, diabetes mellitus, diabetic atherosclerotic disease, diffuse Lewy body disease, dilated congestive cardiomyopathy, disorders of the basal ganglia, Down's syndrome in middle age, drug-induced movement disorders induced by drugs which block CNS dopamine receptors, drug sensitivity, eczema, encephalomyelitis, endocarditis, endocrinopathy, epiglottitis, epstein-barr virus infection, erythromelalgia, extrapyramidal and cerebellar disorders, familial hemophagocytic lymphohistiocytosis, fetal thymus implant rejection, Friedreich's ataxia, functional peripheral arterial disorders, fungal sepsis, gas gangrene, gastric ulcer, glomerular nephritis, graft rejection of any organ or tissue, gram negative sepsis, gram positive sepsis, granulomas due to intracellular organisms, hairy cell leukemia, Hallervorden-Spatz disease, Hashimoto's thyroiditis, hay fever, heart transplant rejection, hemochromatosis, hemodialysis, hemolytic uremic syndrome/thrombolytic thrombocytopenic purpura, hemorrhage, hepatitis A, His bundle arrhythmias, HIV infection/HIV neuropathy, Hodgkin's disease, hyperkinetic movement disorders, hypersensitivity reactions, hypersensitivity pneumonitis, hypertension, hypokinetic movement disorders, hypothalamic-pituitary-adrenal axis evaluation, idiopathic Addison's disease, idiopathic pulmonary fibrosis, antibody mediated cytotoxicity, Asthenia, infantile spinal muscular atrophy, inflammation of the aorta, influenza a, ionizing radiation exposure, iridocyclitis/uveitis/optic neuritis, ischemia- reperfusion injury, ischemic stroke, juvenile rheumatoid arthritis, juvenile spinal muscular atrophy, Kaposi's sarcoma, kidney transplant rejection, legionella, leishmaniasis, leprosy, lesions of the corticospinal system, lipedema, liver transplant rejection, lymphedema, malaria, malignant lymphoma, malignant histiocytosis, malignant melanoma, meningitis, meningococemia, metabolic/idiopathic, migraine headache, mitochondrial multi.system disorder, mixed connective tissue disease, monoclonal gammopathy, multiple myeloma, multiple systems degenerations (Mencel Dejerine-Thomas Shi-Drager and Machado-Joseph), mycobacterium avium intracellulare, mycobacterium tuberculosis, myelodysplastic syndrome, myocardial infarction, myocardial ischemic disorders, nasopharyngeal carcinoma, neonatal chronic lung disease, nephritis, nephrosis, neurodegenerative diseases, neurogenic muscular atrophies, neutropenic fever, non-hodgkins lymphoma, occlusion of the abdominal aorta and its branches, occlusive arterial disorders, okt3 therapy, orchitis/epididymitis, orchitis/vasectomy reversal procedures, organomegaly, osteoporosis, pancreas transplant rejection, pancreatic carcinoma, paraneoplastic

syndrome/hypercalcemia of malignancy, parathyroid transplant rejection, pelvic inflammatory disease, perennial rhinitis, pericardial disease, peripheral atherosclerotic disease, peripheral vascular disorders, peritonitis, pernicious anemia, pneumocystis carinii pneumonia, pneumonia, POEMS syndrome (polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy, and skin changes syndrome), post perfusion syndrome, post pump syndrome, post-MI cardiomyopathy syndrome, preeclampsia, progressive supranuclear palsy, primary pulmonary hypertension, radiation therapy, Raynaud's phenomenon and disease, Raynaud's disease, Refsum's disease, regular narrow QRS tachycardia, renovascular hypertension, reperfusion injury, restrictive cardiomyopathy, sarcomas, scleroderma, senile chorea, senile dementia of Lewy body type, seronegative arthropathies, shock, sickle cell anemia, skin allograft rejection, skin changes syndrome, small bowel transplant rejection, solid tumors, specific arrhythmias, spinal ataxia, spinocerebellar degenerations, streptococcal myositis, structural lesions of the cerebellum, subacute sclerosing panencephalitis, syncope, syphilis of the cardiovascular system, systemic anaphylaxis, systemic inflammatory response syndrome, systemic onset juvenile rheumatoid arthritis, T-cell or FAB ALL telangiectasia, thromboangitis obliterans, thrombocytopenia, toxicity, transplants, trauma/hemorrhage, type III hypersensitivity reactions, type IV hypersensitivity, unstable angina, uremia, urosepsis, valvular heart diseases, varicose veins, vasculitis, venous diseases, venous thrombosis, ventricular fibrillation, viral and fungal infections, viral encephalitis/aseptic meningitis, viral-associated hemophagocytic syndrome, Wernicke-Korsakoff syndrome, Wilson's disease, xenograft rejection of any organ or tissue, acute coronary syndromes, acute idiopathic polyneuritis, acute inflammatory demyelinating polyradiculoneuropathy, acute ischemia, adult Still's disease, anaphylaxis, anti-phospholipid antibody syndrome, aplastic anemia, atopic eczema, atopic dermatitis, autoimmune dermatitis, autoimmune disorder associated with streptococcus infection, autoimmune enteropathy, autoimmune hearing loss, autoimmune lymphoproliferative syndrome (ALPS), autoimmune myocarditis, autoimmune premature ovarian failure, blepharitis, bronchiectasis, bullous pemphigoid, cardiovascular disease, catastrophic antiphospholipid syndrome, celiac disease, cervical spondylosis, chronic ischemia, cicatricial pemphigoid, clinically isolated syndrome (CIS) with risk for multiple sclerosis, childhood onset psychiatric disorder, dacryocystitis, dermatomyositis, diabetic retinopathy, disk herniation, disk prolapse, drug induced immune hemolytic anemia, endometriosis, endophthalmitis, episcleritis, erythema multiforme, erythema multiforme major, gestational pemphigoid, Guillain-Barré syndrome (GBS), Hughes

syndrome, idiopathic Parkinson's disease, idiopathic interstitial pneumonia, IgE-mediated allergy, immune hemolytic anemia, inclusion body myositis, infectious ocular inflammatory disease, inflammatory demyelinating disease, inflammatory heart disease, inflammatory kidney disease, IPF/UIP, iritis, keratitis, keratoconjunctivitis sicca, Kussmaul disease or Kussmaul-Meier disease, Landry's paralysis, Langerhan's cell histiocytosis, livedo reticularis, macular degeneration, microscopic polyangiitis, morbus bechterev, motor neuron disorders, mucous membrane pemphigoid, multiple organ failure, myasthenia gravis, myelodysplastic syndrome, myocarditis, nerve root disorders, neuropathy, non-A non-B hepatitis, optic neuritis, osteolysis, pauciarticular JRA, peripheral artery occlusive disease (PAOD), peripheral vascular disease (PVD), peripheral artery, disease (PAD), phlebitis, polyarteritis nodosa (or periarteritis nodosa), polychondritis, poliosis, polyarticular JRA, polyendocrine deficiency syndrome, polymyositis, polymyalgia rheumatica (PMR), primary Parkinsonism, prostatitis, pure red cell aplasia, primary adrenal insufficiency, recurrent neuromyelitis optica, restenosis, rheumatic heart disease, sapho (synovitis, acne, pustulosis, hyperostosis, and osteitis), secondary amyloidosis, shock lung, scleritis, sciatica, secondary adrenal insufficiency, silicone associated connective tissue disease, sneddon-wilkinson dermatosis, spondylitis ankylosans, Stevens-Johnson syndrome (SJS), temporal arteritis, toxoplasmic retinitis, toxic epidermal necrolysis, transverse myelitis, TRAPS (tumor necrosis factor receptor, type 1 allergic reaction, type II diabetes, urticaria, usual interstitial pneumonia (UIP), vasculitis, vernal conjunctivitis, viral retinitis, Vogt-Koyanagi-Harada syndrome (VKH syndrome), wet macular degeneration, or wound healing. In some embodiments, any one of the binding proteins disclosed herein can be used to treat a disorder listed above. In certain embodiments, the binding protein used to treat any of the disorders discussed herein is one or more of DVD2424-3425. In certain embodiments, the binding protein is DVD2424, DVD2425, DVD2426, DVD2427, DVD2428, DVD2429, DVD2430, DVD3415, or DVD3418. In certain embodiments, the binding protein is DVD3415 or DVD3418. In some embodiments, effective treatment of a disorder using a binding protein (e.g., DVD3418) can be detected by measuring a reduction in expression of one or more of the serum or tissue markers IL-6, PGE-2, G-CSF, CXCL-1, CXCL-5, MMP-3, or MMP-13.

[086] In an embodiment, a binding protein disclosed herein is used to treat an inflammatory, autoimmune, and/or neurological disorder. In an embodiment, a binding protein disclosed herein is used to treat arthritis, rheumatoid arthritis, psoriatic

arthritis, ankylosing spondylitis, axial spondyloarthritis (axSpA), ANCA vasculitis, Crohn's disease, juvenile idiopathic arthritis, psoriasis, ulcerative colitis, intestinal behcet disease, polymyalgia rheumatica, or dry eye. In an embodiment, the binding protein is used to treat arthritis. In an embodiment, the binding protein is used to treat rheumatoid arthritis. In an embodiment, the binding protein is used to treat psoriatic arthritis. In an embodiment, the binding protein is used to treat ankylosing spondylitis. In some embodiments, the binding protein is one or more of DVD2424-3425. In certain embodiments, the binding protein is DVD2424, DVD2425, DVD2426, DVD2427, DVD2428, DVD2429, DVD2430, DVD3415, or DVD3418. In an embodiment, the binding protein is DVD3415 or DVD3418.

[087] In some embodiments, a binding protein (e.g., DVD3415 or DVD3418) may be used to treat rheumatoid arthritis that is resistant to anti-TNF therapy. For instance, a binding protein targeting IL-1 β and IL-17 (e.g., DVD3415 or DVD3418) may persist in circulation longer than an anti-TNF antibody, thereby providing for a longer-duration treatment effect and enabling the potential for reduced administration frequency, which in turn may reduce the risk of the administered agent inducing an immune response. While inhibition of TNF may demonstrate superior treatment benefits in animal models of arthritis than inhibition of either IL-1 β or IL-17 alone, it has surprisingly been discovered that the dual inhibition of both IL-1 β and IL-17 may provide for certain improved treatment outcomes, as compared to anti-TNF monotherapy.

[088] In some embodiments, a binding protein may produce a greater reduction in inflammation associated with rheumatoid arthritis than can be achieved by administering an anti-TNF antibody, or a greater reduction than is achieved by the sum of inhibition after dual administration of separate antibodies to IL-1 β and IL-17. Inflammation may be evaluated, e.g., by measuring the level of IL-6, CXCL-1, PGE-2, CXCL-5, G-CSF, or MMP3 expression. In some embodiments, a binding protein may be used to reduce inflammation, cartilage loss, and/or bone destruction by an amount greater than can be achieved using a TNF antibody or using IL-1 β and IL-17 antibodies administered as a combination of monotherapies. For instance, a binding protein disclosed herein may demonstrate increased reduction in inflammation in a mouse collagen-induced arthritis (CIA) model, as compared to either an IL-1 β or -IL-17 antibody when administered alone. In some embodiments, binding protein may also surprisingly provide bone-protective effects in a TNF-independent manner. Therefore, targeting a combination of inflammatory mediators using a binding protein

(e.g., DVD3415 or DVD3418) may more fully control a patient's symptoms than could be achieved by individual monotherapies.

[089] In certain embodiments, a binding protein (e.g., DVD3415 or DVD3418) can be administered to treat rheumatoid arthritis in a patient population that is resistant to treatment with anti-TNF antibodies. In certain embodiments, a binding protein (e.g., DVD3415 or DVD3418) may be administered to treat rheumatoid arthritis at a late phase of the disease that may not be responsive to anti-TNF therapy (a segment of patients with arthritis do not respond to treatment with anti-TNF agents or anti-cytokine monotherapies). In some embodiments, a binding protein (e.g., DVD3415 or DVD3418) may be used to reduce elevated levels of IL-1 β and IL-17 associated with polymyalgia rheumatica without altering IFN-gamma production in TH1 cells. In some embodiments, a binding protein (e.g., DVD3418) may be used to reduce expression of IL-1 β and IL-17 found in the tears of dry eye patients and associated with dry-eye related inflammation.

[090] In an embodiment, the binding proteins, or antigen-binding portions thereof, are used to treat cancer or in the prevention or inhibition of metastases from the tumors described herein either when used alone or in combination with radiotherapy and/or chemotherapeutic agents.

[091] In another aspect, methods of treating a patient suffering from a disorder comprising the step of administering any one of the binding proteins disclosed herein before, concurrently, or after the administration of a second agent, are provided. In an embodiment, the second agent is budenoside, epidermal growth factor, a corticosteroid, cyclosporin, sulfasalazine, an aminosalicylate, 6-mercaptopurine, azathioprine, metronidazole, a lipoxigenase inhibitor, mesalamine, olsalazine, balsalazide, an antioxidant, a thromboxane inhibitor, an IL-1 receptor antagonist, an anti-IL-1 β mAbs, an anti-IL-6 or IL-6 receptor mAb, a growth factor, an elastase inhibitor, a pyridinyl-imidazole compound, an antibody or agonist of TNF, LT, IL-1, IL-2, IL-6, IL-7, IL-8, IL-12, IL-13, IL-15, IL-16, IL-18, IL-23, EMAP-II, GM-CSF, FGF, or PDGF, an antibody to CD2, CD3, CD4, CD8, CD-19, CD25, CD28, CD30, CD40, CD45, CD69, CD90 or a ligand thereof, methotrexate, cyclosporin, FK506, rapamycin, mycophenolate mofetil, leflunomide, an NSAID, ibuprofen, prednisolone, a phosphodiesterase inhibitor, an adenosine agonist, an antithrombotic agent, a complement inhibitor, an adrenergic agent, IRAK, NIK, IKK, p38, a MAP kinase inhibitor, an IL-1 β converting enzyme inhibitor, a TNF α -converting enzyme inhibitor, a

T-cell signalling inhibitor, a metalloproteinase inhibitor, sulfasalazine, azathioprine, a 6-mercaptopurine, an angiotensin converting enzyme inhibitor, a soluble cytokine receptor, a soluble p55 TNF receptor, a soluble p75 TNF receptor, sIL-1RI, sIL-1RII, sIL-6R, an antiinflammatory cytokine, IL-4, IL-10, IL-11, IL-13, or TGF β . In a particular embodiment, the pharmaceutical compositions disclosed herein are administered to a patient by parenteral, subcutaneous, intramuscular, intravenous, intrarticular, intrabronchial, intraabdominal, intracapsular, intracartilaginous, intracavitary, intracelial, intracerebellar, intracerebroventricular, intracolic, intracervical, intragastric, intrahepatic, intramyocardial, intraosteal, intrapelvic, intrapericardiac, intraperitoneal, intrapleural, intraprostatic, intrapulmonary, intrarectal, intrarenal, intraretinal, intraspinal, intrasynovial, intrathoracic, intrauterine, intravesical, bolus, vaginal, rectal, buccal, sublingual, intranasal, or transdermal administration.

[092] Anti-idiotypic antibodies to the binding proteins disclosed herein are also provided. An anti-idiotypic antibody includes any protein or peptide-containing molecule that comprises at least a portion of an immunoglobulin molecule such as, but not limited to, at least one complementarily determining region (CDR) of a heavy or light chain or a ligand binding portion thereof, a heavy chain or light chain variable region, a heavy chain or light chain constant region, a framework region, or any portion thereof, that can be incorporated into a binding protein provided herein.

[093] A method of determining the presence, amount or concentration of IL-1 β and/or IL-17, or fragment thereof, in a test sample is provided. The method comprises assaying the test sample for the antigen, or fragment thereof, by an immunoassay. The immunoassay (i) employs at least one binding protein and at least one detectable label and (ii) comprises comparing a signal generated by the detectable label as a direct or indirect indication of the presence, amount or concentration of the antigen, or fragment thereof, in the test sample to a signal generated as a direct or indirect indication of the presence, amount or concentration of the antigen, or fragment thereof, in a control or a calibrator. The calibrator is optionally part of a series of calibrators in which each of the calibrators differs from the other calibrators in the series by the concentration of the antigen, or fragment thereof. The method can comprise (i) contacting the test sample with at least one capture agent, which binds to an epitope on the antigen, or fragment thereof, so as to form a capture agent/antigen, or fragment thereof, complex, (ii) contacting the capture agent/antigen, or fragment thereof, complex with at least one detection agent, which comprises a detectable label and binds to an epitope on the antigen, or fragment

thereof, that is not bound by the capture agent, to form a capture agent/antigen, or fragment thereof/detection agent complex, and (iii) determining the presence, amount or concentration of the antigen, or fragment thereof, in the test sample based on the signal generated by the detectable label in the capture agent/antigen, or fragment thereof/detection agent complex formed in (ii), wherein at least one capture agent and/or at least one detection agent is the at least one binding protein.

[094] Alternatively, the method can comprise (i) contacting the test sample with at least one capture agent, which binds to an epitope on the antigen, or fragment thereof, so as to form a capture agent/antigen, or fragment thereof, complex, and simultaneously or sequentially, in either order, contacting the test sample with detectably labeled antigen, or fragment thereof, which can compete with any antigen, or fragment thereof, in the test sample for binding to the at least one capture agent, wherein any antigen, or fragment thereof, present in the test sample and the detectably labeled antigen compete with each other to form a capture agent/antigen, or fragment thereof, complex and a capture agent/detectably labeled antigen, or fragment thereof, complex, respectively, and (ii) determining the presence, amount or concentration of the antigen, or fragment thereof, in the test sample based on the signal generated by the detectable label in the capture agent/detectably labeled antigen, or fragment thereof, complex formed in (ii), wherein at least one capture agent is the at least one binding protein and wherein the signal generated by the detectable label in the capture agent/detectably labeled antigen, or fragment thereof, complex is inversely proportional to the amount or concentration of antigen, or fragment thereof, in the test sample.

[095] The test sample can be from a patient, in which case the method can further comprise diagnosing, prognosticating, or assessing the efficacy of therapeutic/prophylactic treatment of the patient. If the method further comprises assessing the efficacy of therapeutic/prophylactic treatment of the patient, the method optionally further comprises modifying the therapeutic/prophylactic treatment of the patient as needed to improve efficacy. The method can be adapted for use in an automated system or a semi-automated system. Accordingly, the methods described herein also can be used to determine whether or not a subject has or is at risk of developing a given disease, disorder or condition. Specifically, such a method can comprise the steps of:

[096] (a) determining the concentration or amount in a test sample from a subject of analyte, or fragment thereof, (e.g., using the methods described herein, or methods known in the art); and

[097] (b) comparing the concentration or amount of analyte, or fragment thereof, determined in step (a) with a predetermined level, wherein, if the concentration or amount of analyte determined in step (a) is favorable with respect to a predetermined level, then the subject is determined not to have or be at risk for a given disease, disorder or condition. However, if the concentration or amount of analyte determined in step (a) is unfavorable with respect to the predetermined level, then the subject is determined to have or be at risk for a given disease, disorder or condition.

[098] Additionally, provided herein is method of monitoring the progression of disease in a subject. Optimally the method comprising the steps of: (a) determining the concentration or amount in a test sample from a subject of analyte; (b) determining the concentration or amount in a later test sample from the subject of analyte; and (c) comparing the concentration or amount of analyte as determined in step (b) with the concentration or amount of analyte determined in step (a), wherein if the concentration or amount determined in step (b) is unchanged or is unfavorable when compared to the concentration or amount of analyte determined in step (a), then the disease in the subject is determined to have continued, progressed or worsened. By comparison, if the concentration or amount of analyte as determined in step (b) is favorable when compared to the concentration or amount of analyte as determined in step (a), then the disease in the subject is determined to have discontinued, regressed or improved.

[099] Optionally, the method further comprises comparing the concentration or amount of analyte as determined in step (b), for example, with a predetermined level. Further, optionally the method comprises treating the subject with one or more pharmaceutical compositions for a period of time if the comparison shows that the concentration or amount of analyte as determined in step (b), for example, is unfavorably altered with respect to the predetermined level.

[0100] Also provided is a kit for assaying a test sample for IL-1 β and/or IL-17, or fragment thereof. The kit comprises at least one component for assaying the test sample for an antigen, or fragment thereof, and instructions for assaying the test sample for an antigen, or fragment thereof, wherein the at least one component

includes at least one composition comprising the binding protein disclosed herein, wherein the binding protein is optionally detectably labeled.

[0101] Multivalent and/or multispecific binding proteins capable of binding IL-1 β and/or IL-17 are provided. Dual variable domain binding proteins or molecules (DVD binding proteins or DVD molecules), or dual variable domain immunoglobulin (DVD-IgTM) proteins, and pharmaceutical compositions thereof, as well as nucleic acids, recombinant expression vectors and host cells for making such DVD-Ig binding proteins are also provided. Methods of using the DVD-Ig binding proteins to detect specific antigens, either in vitro or in vivo are also provided.

[0102] Unless otherwise defined herein, scientific and technical terms used herein have the meanings that are commonly understood by those of ordinary skill in the art. In the event of any latent ambiguity, definitions provided herein take precedent over any dictionary or extrinsic definition. Unless otherwise required by context, singular terms shall include pluralities and plural terms shall include the singular. The use of "or" means "and/or" unless stated otherwise. The use of the term "including", as well as other forms, such as "includes" and "included", is not limiting. Any range disclosed herein is intended to encompass the endpoints of that range unless stated otherwise.

[0103] Generally, nomenclatures used in connection with cell and tissue culture, molecular biology, immunology, microbiology, genetics and protein and nucleic acid chemistry and hybridization described herein are those known and commonly used in the art. The methods and techniques provided herein are generally performed according to conventional methods well known in the art and as described in various general and more specific references that are cited and discussed throughout the present specification unless otherwise indicated. Enzymatic reactions and purification techniques are performed according to manufacturer's specifications, as commonly accomplished in the art or as described herein. The nomenclatures used in connection with, and the laboratory procedures and techniques of, analytical chemistry, synthetic organic chemistry, and medicinal and pharmaceutical chemistry described herein are those well known and commonly used in the art. Standard techniques are used for chemical syntheses, chemical analyses, pharmaceutical preparation, formulation, and delivery, and treatment of patients.

[0104] That the disclosure may be more readily understood, select terms are defined below.

[0105] The term "antibody" refers to an immunoglobulin (Ig) molecule, which is generally comprised of four polypeptide chains, two heavy (H) chains and two light (L) chains, or a functional fragment, mutant, variant, or derivative thereof, that retains the epitope binding features of an Ig molecule. Such fragment, mutant, variant, or derivative antibody formats are known in the art. In an embodiment of a full-length antibody, each heavy chain is comprised of a heavy chain variable region (VH) and a heavy chain constant region (CH). The CH is comprised of three domains, CH1, CH2 and CH3. Each light chain is comprised of a light chain variable region (VL) and a light chain constant region (CL). The CL is comprised of a single CL domain. The VH and VL can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDRs), interspersed with regions that are more conserved, termed framework regions (FRs). Generally, 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, and FR4. 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.

[0106] The term "bispecific antibody" refers to an antibody that binds one antigen (or epitope) on one of its two binding arms (one pair of HC/LC), and binds a different antigen (or epitope) on its second binding arm (a different pair of HC/LC). A bispecific antibody has two distinct antigen binding arms (in both specificity and CDR sequences), and is monovalent for each antigen to which it binds. Bispecific antibodies include those generated by quadroma technology (Milstein and Cuello (1983) *Nature* 305(5934): 537-40), by chemical conjugation of two different monoclonal antibodies (Staerz et al. (1985) *Nature* 314(6012): 628-31), or by knob-into-hole or similar approaches which introduces mutations in the Fc region (Holliger et al. (1993) *Proc. Natl. Acad. Sci. USA* 90(14): 6444-6448).

[0107] An "affinity matured" antibody or binding protein refers to an antibody or binding protein with one or more alterations in one or more CDR or framework (FR) regions thereof, which result an improvement in the affinity for an antigen, compared to a parent antibody or binding protein which does not possess those alteration(s). Exemplary affinity matured antibodies or binding protein will have nanomolar or even picomolar affinities for the target antigen. Affinity matured antibodies or binding protein may be produced by procedures known in the art, e.g., Marks et al. (1992) *BioTechnology* 10:779-783 describes affinity maturation by VH and VL domain shuffling. Random mutagenesis of CDR and/or framework residues is described by

Barbas et al. (1994) Proc. Nat. Acad. Sci. USA 91:3809-3813; Schier et al. (1995) Gene 169:147-155; Yelton et al. (1995) J. Immunol. 155:1994-2004; Jackson et al. (1995) J. Immunol. 154(7):3310-9; Hawkins et al. (1992) J. Mol. Biol. 226:889-896 and mutation at selective mutagenesis positions, contact or hypermutation positions with an activity enhancing amino acid residue as described in US Patent No. 6,914,128.

[0108] The term "CDR-grafted" antibody or binding protein refers to an antibody or binding protein that comprises heavy and light chain variable region sequences in which the sequences of one or more of the CDR regions of VH and/or VL are replaced with CDR sequences of another antibody or binding protein. For example, the two antibodies or binding protein can be from different species, such as antibodies or binding protein having murine heavy and light chain variable regions in which one or more of the murine CDRs has been replaced with human CDR sequences.

[0109] The term "humanized" antibody or binding protein refers to an antibody or binding protein from a non-human species that has been altered to be more "human-like", i.e., more similar to human germline sequences. One type of humanized antibody or binding protein is a CDR-grafted antibody or binding protein, in which non-human CDR sequences are introduced into human VH and VL sequences to replace the corresponding human CDR sequences. A humanized antibody or binding protein also encompasses a variant, derivative, analog or fragment of an antibody or or binding protein that comprises framework region (FR) sequences having substantially (e.g., at least 80%, at least 85%, at least 90%, at least 95%, at least 98% or at least 99% identity to) the amino acid sequence of a human antibody and at least one CDR having substantially the amino acid sequence of a non-human antibody. A humanized antibody or binding protein may comprise substantially all of at least one variable domain (Fab, Fab', F(ab')₂, FabC, Fv) in which the sequence of all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin (i.e., donor antibody) and the sequence of all or substantially all of the FR regions are those of a human immunoglobulin. The humanized antibody or binding protein also may include the CH1, hinge, CH2, CH3, and CH4 regions of the heavy chain. In an embodiment, a humanized antibody or binding protein may also comprise at least a portion of a human immunoglobulin Fc region. In some embodiments, a humanized antibody or binding protein only contains a humanized light chain. In some embodiments, a humanized antibody or binding protein only contains a humanized heavy chain. In some embodiments, a humanized antibody or binding protein only

contains a humanized variable domain of a light chain and/or humanized variable domain of a heavy chain. In some embodiments, a humanized antibody or binding protein contains a humanized light chain as well as at least a variable domain of a heavy chain. In some embodiments, a humanized antibody or binding protein contains a humanized heavy chain as well as at least a variable domain of a light chain.

[0110] The terms "dual variable domain binding protein" and "dual variable domain immunoglobulin" refer to a binding protein that has two variable domains in each of its two binding arms (e.g., a pair of HC/LC), each of which is able to bind to an antigen, as described in, e.g., U.S. Patent No. 7,612,181 (incorporated herein by reference in its entirety). In an embodiment, each variable domain binds different antigens or epitopes. In another embodiment, each variable domain binds the same antigen or epitope. In another embodiment, a dual variable domain binding protein has two identical antigen binding arms, with identical specificity and identical CDR sequences, and is bivalent for each antigen to which it binds. In an embodiment, the DVD-Ig binding proteins may be monospecific, i.e., capable of binding one antigen or multispecific, i.e., capable of binding two or more antigens. For example, a dual variable domain binding protein may have two, three or four different antigen binding arms, with different specificity and/or different CDR sequences on each arm, and the binding protein may be monovalent, bivalent, or multivalent for each antigen to which it binds. DVD-Ig binding proteins comprising two heavy chain DVD polypeptides and two light chain DVD polypeptides are referred to as DVD-IgTM proteins. In an embodiment, each half of a four chain DVD-Ig binding protein comprises a heavy chain DVD polypeptide, and a light chain DVD polypeptide, and two antigen binding sites. In an embodiment, each binding site comprises a heavy chain variable domain and a light chain variable domain with a total of 6 CDRs involved in antigen binding per antigen binding site.

[0111] The term "antiidiotypic antibody" refers to an antibody raised against the amino acid sequence of the antigen combining site of another antibody. Antiidiotypic antibodies may be administered to enhance an immune response against an antigen.

[0112] The term "biological activity" refers to any one or more biological properties of a molecule (whether present naturally as found in vivo, or provided or enabled by recombinant means). Biological properties include, but are not limited to, binding a receptor, inducing cell proliferation, inhibiting cell growth, inducing other cytokines, inducing apoptosis, and enzymatic activity.

[0113] The term “neutralizing” refers to counteracting the biological activity of an antigen when a binding protein specifically binds to the antigen. In an embodiment, a neutralizing binding protein binds to an antigen (e.g., a cytokine) and reduces the antigen’s biological activity by at least about 20%, about 40%, about 60%, about 80%, about 85%, about 90%, about 95%, or about 100% (or any percentage in between).

[0114] The term “specificity” refers to the ability of a binding protein to selectively bind an antigen.

[0115] The term “affinity” refers to the strength of the interaction between a binding protein and an antigen, and is determined by the sequence of the CDRs of the binding protein as well as by the nature of the antigen, such as its size, shape, and/or charge. Binding proteins may be selected for affinities that provide desired therapeutic end-points while minimizing negative side-effects. Affinity may be measured using methods known to one skilled in the art (see, e.g., US 20090311253).

[0116] The term “potency” refers to the ability of a binding protein to achieve a desired effect, and is a measurement of its therapeutic efficacy. Potency may be assessed using methods known to one skilled in the art (see, e.g., US 20090311253).

[0117] The term “cross-reactivity” refers to the ability of a binding protein to bind a target other than that against which it was raised. Generally, a binding protein will bind its target tissue(s)/antigen(s) with an appropriately high affinity, but will display an appropriately low affinity for non-target normal tissues. Individual binding proteins are generally selected to meet two criteria. (1) tissue staining appropriate for the known expression of the antibody target, and (2) a similar staining pattern between human and toxicity study species (e.g., rat, mouse or cynomolgus monkey) tissues from the same organ. These and other methods of assessing cross-reactivity are known to one skilled in the art (see, e.g., US 20090311253).

[0118] The term “biological function” refers the specific *in vitro* or *in vivo* actions of a binding protein. Binding proteins may target several classes of antigens and achieve desired therapeutic outcomes through multiple mechanisms of action. Binding proteins may target soluble proteins, cell surface antigens, as well as extracellular protein deposits. Binding proteins may agonize, antagonize, or neutralize the activity of their targets. Binding proteins may assist in the clearance of the targets to which they bind, or may result in cytotoxicity when bound to cells. Portions of two or more antibodies may be incorporated into a multivalent format to achieve distinct functions in a single binding protein molecule. The *in vitro* assays and *in vivo* models

used to assess biological function are known to one skilled in the art (see, e.g., US 20090311253).

[0119] The term "stable" binding protein refers to one in which the binding protein essentially retains its physical stability, chemical stability and/or biological activity upon storage. A multivalent binding protein that is stable *in vitro* at various temperatures for an extended period of time is desirable. Methods of stabilizing binding proteins and assessing their stability at various temperatures are known to one skilled in the art (see, e.g., US 20090311253).

[0120] The term "solubility" refers to the ability of a protein to remain dispersed within an aqueous solution. The solubility of a protein in an aqueous formulation depends upon the proper distribution of hydrophobic and hydrophilic amino acid residues, and therefore, solubility can correlate with the production of correctly folded proteins. A person skilled in the art will be able to detect an increase or decrease in solubility of a binding protein using routine HPLC techniques and methods known to one skilled in the art (see, e.g., US 20090311253).

[0121] Binding proteins may be produced using a variety of host cells or may be produced *in vitro*, and the relative yield per effort determines the "production efficiency." Factors influencing production efficiency include, but are not limited to, host cell type (prokaryotic or eukaryotic), choice of expression vector, choice of nucleotide sequence, and methods employed. The materials and methods used in binding protein production, as well as the measurement of production efficiency, are known to one skilled in the art (US 20090311253).

[0122] The term "immunogenicity" means the ability of a substance to induce an immune response. Administration of a therapeutic binding protein may result in a certain incidence of an immune response. Potential elements that might induce immunogenicity in a multivalent format may be analyzed during selection of the parental antibodies, and steps to reduce such risk can be taken to optimize the parental antibodies prior to incorporating their sequences into a multivalent binding protein format. Methods of reducing the immunogenicity of antibodies and binding proteins are known to one skilled in the art (US 20090311253).

[0123] The terms "label" and "detectable label" refer to a moiety attached to a member of a specific binding pair, such as an antibody/binding protein or its analyte to render a reaction (e.g., binding) between the members of the specific binding pair, detectable. The labeled member of the specific binding pair is referred to as

“detectably labeled.” Thus, the term “labeled binding protein” refers to a protein with a label incorporated that provides for the identification of the binding protein. In an embodiment, the label is a detectable marker that can produce a signal that is detectable by visual or instrumental means, e.g., incorporation of a radiolabeled amino acid or attachment to a polypeptide of biotinyl moieties that can be detected by marked avidin (e.g., streptavidin containing a fluorescent marker or enzymatic activity that can be detected by optical or colorimetric methods). Examples of labels for polypeptides include, but are not limited to, the following: radioisotopes or radionuclides (e.g., ^3H , ^{14}C , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I , ^{177}Lu , ^{166}Ho , or ^{153}Sm); chromogens, fluorescent labels (e.g., FITC, rhodamine, lanthanide phosphors), enzymatic labels (e.g., horseradish peroxidase, luciferase, alkaline phosphatase); chemiluminescent markers; biotinyl groups; predetermined polypeptide epitopes recognized by a secondary reporter (e.g., leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains, epitope tags); and magnetic agents, such as gadolinium chelates. Representative examples of labels commonly employed for immunoassays include moieties that produce light, e.g., acridinium compounds, and moieties that produce fluorescence, e.g., fluorescein. In this regard, the moiety itself may not be detectably labeled but may become detectable upon reaction with yet another moiety.

[0124] The term “conjugate” refers to a binding protein that is chemically linked to a second chemical moiety, such as a therapeutic or cytotoxic agent. The term “agent” includes a chemical compound, a mixture of chemical compounds, a biological macromolecule, or an extract made from biological materials. In an embodiment, the therapeutic or cytotoxic agents include, but are not limited to, pertussis toxin, taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or homologs thereof. When employed in the context of an immunoassay, the conjugate antibody may be a detectably labeled antibody used as the detection antibody.

[0125] The terms “crystal” and “crystallized” refer to a binding protein (e.g., an antibody), or antigen binding portion thereof, that exists in the form of a crystal. Crystals are one form of the solid state of matter, which is distinct from other forms such as the amorphous solid state or the liquid crystalline state. Crystals are

composed of regular, repeating, three-dimensional arrays of atoms, ions, molecules (e.g., proteins such as antibodies), or molecular assemblies (e.g., antigen/antibody complexes). These three-dimensional arrays are arranged according to specific mathematical relationships that are well-understood in the field. The fundamental unit, or building block, that is repeated in a crystal is called the asymmetric unit. Repetition of the asymmetric unit in an arrangement that conforms to a given, well-defined crystallographic symmetry provides the "unit cell" of the crystal. Repetition of the unit cell by regular translations in all three dimensions provides the crystal. See Giege, R. and Ducruix, A. Barrett, CRYSTALLIZATION OF NUCLEIC ACIDS AND PROTEINS, A PRACTICAL APPROACH, 2nd ea., pp. 20 1-16, Oxford University Press, New York, New York, (1999).

[0126] The term "vector" refers to a nucleic acid molecule capable of transporting another nucleic acid to which it has been linked. One type of vector is a "plasmid", which refers to a circular double stranded DNA loop into which additional DNA segments may be ligated. Another type of vector is a viral vector, wherein additional DNA segments may be ligated into the viral genome. Other vectors include RNA vectors. Certain vectors are capable of autonomous replication in a host cell into which they are introduced (e.g., bacterial vectors having a bacterial origin of replication and episomal mammalian vectors). Other vectors (e.g., non-episomal mammalian vectors) can be integrated into the genome of a host cell upon introduction into the host cell, and thereby are replicated along with the host genome. Certain vectors are capable of directing the expression of genes to which they are operatively linked. Such vectors are referred to herein as "recombinant expression vectors" (or simply, "expression vectors"). In general, expression vectors of utility in recombinant DNA techniques are often in the form of plasmids. In the present specification, "plasmid" and "vector" may be used interchangeably as the plasmid is the most commonly used form of vector. However, other forms of expression vectors are also included, such as viral vectors (e.g., replication defective retroviruses, adenoviruses and adeno-associated viruses), which serve equivalent functions. A group of pHybE vectors (e.g., US Patent 8,187,836) may be used for parental antibody and DVD-binding protein cloning. V1, derived from pJP183; pHybE-hCg1,z,non-a V2, may be used for cloning of antibody and DVD heavy chains with a wildtype constant region. V2, derived from pJP191; pHybE-hCk V3, may be used for cloning of antibody and DVD light chains with a kappa constant region. V3, derived from pJP192; pHybE-hCl V2, may be used for cloning of antibody and DVD light

chains with a lambda constant region. V4, built with a lambda signal peptide and a kappa constant region, may be used for cloning of DVD light chains with a lambda-kappa hybrid V domain. V5, built with a kappa signal peptide and a lambda constant region, may be used for cloning of DVD light chains with a kappa-lambda hybrid V domain. V7, derived from pJP183; pHybE-hCg1,z,non-a V2, may be used for cloning of antibody and DVD heavy chains with a (234,235 AA) mutant constant region.

[0127] The terms "recombinant host cell" or "host cell" refer to a cell into which exogenous DNA has been introduced. Such terms refer not only to the particular subject cell, but to the progeny of such a cell. Because certain modifications may occur in succeeding generations due to either mutation or environmental influences, such progeny may not, in fact, be identical to the parent cell, but are still included within the scope of the term "host cell" as used herein. In an embodiment, host cells include prokaryotic and eukaryotic cells. In an embodiment, eukaryotic cells include protist, fungal, plant and animal cells. In another embodiment, host cells include but are not limited to the prokaryotic cell line *E. Coli*; mammalian cell lines CHO, HEK 293, COS, NS0, SP2 and PER.C6; the insect cell line Sf9; and the fungal cell *Saccharomyces cerevisiae*.

[0128] The term "transfection" encompasses a variety of techniques commonly used for the introduction of exogenous nucleic acid (e.g., DNA) into a host cell, e.g., electroporation, calcium-phosphate precipitation, DEAE-dextran transfection and the like.

[0129] The term "cytokine" refers to a protein released by one cell population that acts on another cell population as an intercellular mediator. The term "cytokine" includes proteins from natural sources or from recombinant cell culture and biologically active equivalents of the native sequence cytokines.

[0130] The term "biological sample" refers to a quantity of a substance from a living thing or formerly living thing. Such substances include, but are not limited to, blood, (e.g., whole blood), plasma, serum, urine, amniotic fluid, synovial fluid, endothelial cells, leukocytes, monocytes, other cells, organs, tissues, bone marrow, lymph nodes and spleen.

[0131] The term "component" refers to an element of a composition. In relation to a diagnostic kit, for example, a component may be a capture antibody, a detection or conjugate antibody, a control, a calibrator, a series of calibrators, a sensitivity panel, a container, a buffer, a diluent, a salt, an enzyme, a co-factor for an

enzyme, a detection reagent, a pretreatment reagent/solution, a substrate (e.g., as a solution), a stop solution, and the like that can be included in a kit for assay of a test sample. Thus, a "component" can include a polypeptide or other analyte as above, that is immobilized on a solid support, such as by binding to an anti-analyte (e.g., anti-polypeptide) antibody. Some components can be in solution or lyophilized for reconstitution for use in an assay.

[0132] "Control" refers to a composition known to not analyte ("negative control") or to contain analyte ("positive control"). A positive control can comprise a known concentration of analyte. "Control," "positive control," and "calibrator" may be used interchangeably herein to refer to a composition comprising a known concentration of analyte. A "positive control" can be used to establish assay performance characteristics and is a useful indicator of the integrity of reagents (e.g., analytes).

[0133] "Predetermined cutoff" and "predetermined level" refer generally to an assay cutoff value that is used to assess diagnostic/prognostic/therapeutic efficacy results by comparing the assay results against the predetermined cutoff/level, where the predetermined cutoff/level already has been linked or associated with various clinical parameters (e.g., severity of disease, progression/nonprogression/improvement, etc.). While the present disclosure may provide exemplary predetermined levels, it is well-known that cutoff values may vary depending on the nature of the immunoassay (e.g., antibodies employed, etc.). It further is well within the ordinary skill of one in the art to adapt the disclosure herein for other immunoassays to obtain immunoassay-specific cutoff values for those other immunoassays based on this disclosure. Whereas the precise value of the predetermined cutoff/level may vary between assays, correlations as described herein (if any) may be generally applicable.

[0134] "Pretreatment reagent," e.g., lysis, precipitation and/or solubilization reagent, as used in a diagnostic assay as described herein refers to one that lyses any cells and/or solubilizes any analyte that is/are present in a test sample. Pretreatment is not necessary for all samples, as described further herein. Among other things, solubilizing the analyte (e.g., polypeptide of interest) may entail release of the analyte from any endogenous binding proteins present in the sample. A pretreatment reagent may be homogeneous (not requiring a separation step) or heterogeneous (requiring a separation step). With use of a heterogeneous

pretreatment reagent there is removal of any precipitated analyte binding proteins from the test sample prior to proceeding to the next step of the assay.

[0135] "Quality control reagents" in the context of immunoassays and kits described herein, include, but are not limited to, calibrators, controls, and sensitivity panels. A "calibrator" or "standard" typically is used (e.g., one or more, such as a plurality) in order to establish calibration (standard) curves for interpolation of the concentration of an analyte, such as an antibody or an analyte. Alternatively, a single calibrator, which is near a predetermined positive/negative cutoff, can be used. Multiple calibrators (i.e., more than one calibrator or a varying amount of calibrator(s)) can be used in conjunction so as to comprise a "sensitivity panel."

[0136] The term "specific binding partner" refers to a member of a specific binding pair. A specific binding pair comprises two different molecules that specifically bind to each other through chemical or physical means. Therefore, in addition to antigen and antibody specific binding, other specific binding pairs can include biotin and avidin (or streptavidin), carbohydrates and lectins, complementary nucleotide sequences, effector and receptor molecules, cofactors and enzymes, enzyme inhibitors and enzymes, and the like. Furthermore, specific binding pairs can include members that are analogs of the original specific binding members, for example, an analyte-analog. Immunoreactive specific binding members include antigens, antigen fragments, and antibodies, including monoclonal and polyclonal antibodies as well as complexes, fragments, and variants (including fragments of variants) thereof, whether isolated or recombinantly produced.

[0137] The term "Fc region" refers to the C-terminal region of an immunoglobulin heavy chain, which may be generated by papain digestion of an intact antibody or binding protein. The Fc region may be a native sequence Fc region or a variant Fc region. The Fc region of an immunoglobulin generally comprises two constant domains, a CH2 domain and a CH3 domain, and optionally comprises a CH4 domain. Replacements of amino acid residues in the Fc portion to alter effector function are known in the art (e.g., US Patent Nos. 5,648,260 and 5,624,821). The Fc region mediates several important effector functions, e.g., cytokine induction, antibody dependent cell mediated cytotoxicity (ADCC), phagocytosis, complement dependent cytotoxicity (CDC), and half-life/ clearance rate of antibody or binding protein and antigen-antibody or antigen-binding protein complexes. In some cases these effector functions are desirable for a therapeutic immunoglobulin but in other cases might be unnecessary or even deleterious, depending on the therapeutic objectives.

[0138] The term “antigen-binding portion” of a binding protein refers to one or more fragments of a binding protein that retain the ability to specifically bind to an antigen. The antigen-binding portion of a binding protein can be performed by fragments of a full-length binding protein, including bispecific, dual specific, or multi-specific formats; specifically binding to two or more different antigens. Examples of binding fragments encompassed within the term “antigen-binding portion” of an binding protein include (i) an Fab fragment, a monovalent fragment consisting of the VL, VH, CL and CH1 domains; (ii) an F(ab')₂ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) an Fd fragment consisting of the VH and CH1 domains; (iv) an Fv fragment consisting of the VL and VH domains of a single arm of an antibody or binding protein, (v) a dAb fragment, which comprises a single variable domain; and (vi) an isolated complementarity determining region (CDR). Furthermore, although the two domains of the Fv fragment, VL and VH, encoded by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the VL and VH regions pair to form monovalent molecules (known as single chain Fv (scFv). Such single chain antibodies or binding proteins are also intended to be encompassed within the term “antigen-binding portion” of an antibody or binding protein. Other forms of single chain antibodies, such as diabodies are also encompassed. In addition, single chain antibodies or binding protein also include “linear” antibodies or binding protein comprising a pair of tandem Fv segments (VH-CH1-VH-CH1) which, together with complementary light chain polypeptides, form a pair of antigen binding regions.

[0139] The term “multivalent binding protein” refers to a binding protein comprising two or more antigen binding sites. In an embodiment, the multivalent binding protein is engineered to have three or more antigen binding sites, and may not be a naturally occurring antibody. The term “multispecific binding protein” refers to a binding protein capable of binding two or more related or unrelated targets. In an embodiment, the dual variable domain (DVD) binding proteins provided herein comprise two or more antigen binding sites and are tetravalent or multivalent binding proteins.

[0140] The term “linker” refers to an amino acid residue or a polypeptide comprising two or more amino acid residues joined by peptide bonds that are used to link two polypeptides (e.g., two VH or two VL domains). Such linker polypeptides are

well known in the art (see, e.g., Holliger et al. (1993) *Proc. Natl. Acad. Sci. USA* 90:6444-6448; Poljak et al. (1994) *Structure* 2:1121-1123).

[0141] The terms "Kabat numbering", "Kabat definitions" and "Kabat labeling" are used interchangeably herein. These terms, which are recognized in the art, refer to a system of numbering amino acid residues which are more variable (i.e., hypervariable) than other amino acid residues in the heavy and light chain variable regions of an antibody or binding protein, or an antigen binding portion thereof (Kabat et al. (1971) *Ann. NY Acad. Sci.* 190:382-391 and, Kabat et al. (1991) *Sequences of Proteins of Immunological Interest*, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242). For the heavy chain variable region, the hypervariable region ranges from amino acid positions 31 to 35 for CDR1, amino acid positions 50 to 65 for CDR2, and amino acid positions 95 to 102 for CDR3. For the light chain variable region, the hypervariable region ranges from amino acid positions 24 to 34 for CDR1, amino acid positions 50 to 56 for CDR2, and amino acid positions 89 to 97 for CDR3.

[0142] The term "CDR" refers to a complementarity determining region within an immunoglobulin variable region sequence. There are three CDRs in each of the variable regions of the heavy chain and the light chain, which are designated CDR1, CDR2 and CDR3, for each of the heavy and light chain variable regions. The term "CDR set" refers to a group of three CDRs that occur in a single variable region capable of binding the antigen. The exact boundaries of these CDRs have been defined differently according to different systems. The system described by Kabat (Kabat et al. (1987) and (1991)) not only provides an unambiguous residue numbering system applicable to any variable region of an antibody or binding protein, but also provides precise residue boundaries defining the three CDRs in each heavy or light chain sequence. These CDRs may be referred to as Kabat CDRs. Chothia and coworkers (Chothia and Lesk (1987) *J. Mol. Biol.* 196:901-917; Chothia et al. (1989) *Nature* 342:877-883) found that certain sub- portions within Kabat CDRs adopt nearly identical peptide backbone conformations, despite having great diversity at the level of amino acid sequence. These sub-portions were designated as L1, L2 and L3 or H1, H2 and H3 where the "L" and the "H" designates the light chain and the heavy chain regions, respectively. These regions may be referred to as Chothia CDRs, which have boundaries that overlap with Kabat CDRs. Other boundaries defining CDRs overlapping with the Kabat CDRs have been described by Padlan (1995) *FASEB J.* 9:133-139 and MacCallum (1996) *J. Mol. Biol.* 262(5):732-45). Still other CDR

boundary definitions may not strictly follow one of the herein systems, but will nonetheless overlap with the Kabat CDRs, although they may be shortened or lengthened in light of prediction or experimental findings that particular residues or groups of residues or even entire CDRs do not significantly impact antigen binding. The methods used herein may utilize CDRs defined according to any of these systems, although certain embodiments use Kabat or Chothia defined CDRs.

[0143] The term “epitope” refers to a region of an antigen that is bound by a binding protein, e.g., a polypeptide and/or other determinant capable of specific binding to an immunoglobulin or T-cell receptor. In certain embodiments, epitope determinants include chemically active surface groupings of molecules such as amino acids, sugar side chains, phosphoryl, or sulfonyl, and, in certain embodiments, may have specific three dimensional structural characteristics, and/or specific charge characteristics. In an embodiment, an epitope comprises the amino acid residues of a region of an antigen (or fragment thereof) that are recognized by and/or bound by the complementary site on the specific binding partner. An antigenic fragment can contain more than one epitope. In certain embodiments, a binding protein specifically binds an antigen when it recognizes its target antigen in a complex mixture of proteins and/or macromolecules. Binding proteins “bind to the same epitope” if the antibodies or binding proteins cross-compete (one prevents the binding or modulating effect of the other). In addition, structural definitions of epitopes (overlapping, similar, identical) are informative; and functional definitions encompass structural (binding) and functional (modulation, competition) parameters. Different regions of proteins may perform different functions. For example specific regions of a cytokine interact with its cytokine receptor to bring about receptor activation whereas other regions of the protein may be required for stabilizing the cytokine. To abrogate the negative effects of cytokine signaling, the cytokine may be targeted with a binding protein that binds specifically to the receptor interacting region(s), thereby preventing the binding of its receptor. Alternatively, a binding protein may target the regions responsible for cytokine stabilization, thereby designating the protein for degradation. The methods of visualizing and modeling epitope recognition are known to one skilled in the art (US 20090311253).

[0144] The term “pharmacokinetic(s)” refers to the process by which a drug is absorbed, distributed, metabolized, and excreted by an organism. To generate a multivalent binding protein molecule with a desired pharmacokinetic profile, parent monoclonal antibodies with similarly desired pharmacokinetic profiles are selected.

The PK profiles of the selected parental monoclonal antibodies can be easily determined in rodents using methods known to one skilled in the art (see, e.g., US 20090311253).

[0145] The term "bioavailability" refers to the amount of active drug that reaches its target following administration. Bioavailability is function of several of the previously described properties, including stability, solubility, immunogenicity and pharmacokinetics, and can be assessed using methods known to one skilled in the art (see, e.g., US 20090311253).

[0146] The term "surface plasmon resonance" refers to an optical phenomenon that allows for the analysis of real-time biospecific interactions by detection of alterations in protein concentrations within a biosensor matrix, for example using the BIAcore® system (BIAcore International AB, a GE Healthcare company, Uppsala, Sweden and Piscataway, NJ). For further descriptions, see Jönsson et al. (1993) *Ann. Biol. Clin.* 51:19-26. The term " K_{on} " refers to the on rate constant for association of a binding protein (e.g., an antibody or DVD-Ig) to the antigen to form the, e.g., DVD-Ig/antigen complex. The term " K_{on} " also refers to "association rate constant", or " k_a ", as is used interchangeably herein. This value indicating the binding rate of a binding protein to its target antigen or the rate of complex formation between a binding protein, e.g., an antibody, and antigen also is shown by the equation below:



[0147] The term " K_{off} " refers to the off rate constant for dissociation, or "dissociation rate constant", of a binding protein (e.g., an antibody or DVD-Ig) from the, e.g., DVD-Ig/antigen complex as is known in the art. This value indicates the dissociation rate of a binding protein, e.g., an antibody, from its target antigen or separation of Ab-Ag complex over time into free antibody and antigen as shown by the equation below:



[0148] The terms " K_d " and "equilibrium dissociation constant" refer to the value obtained in a titration measurement at equilibrium, or by dividing the dissociation rate constant (K_{off}) by the association rate constant (K_{on}). The association rate constant, the dissociation rate constant and the equilibrium

dissociation constant, are used to represent the binding affinity of a binding protein (e.g., an antibody or DVD-Ig) to an antigen. Methods for determining association and dissociation rate constants are well known in the art. Using fluorescence-based techniques offers high sensitivity and the ability to examine samples in physiological buffers at equilibrium. Other experimental approaches and instruments such as a BIAcore® (biomolecular interaction analysis) assay, can be used (e.g., instrument available from BIAcore International AB, a GE Healthcare company, Uppsala, Sweden). Additionally, a KinExA® (Kinetic Exclusion Assay) assay, available from Sapidyne Instruments (Boise, Idaho), can also be used.

[0149] The term “variant” refers to a polypeptide that differs from a given polypeptide in amino acid sequence by the addition (e.g., insertion), deletion, or conservative substitution of amino acids, but that retains the biological activity of the given polypeptide (e.g., a variant IL-17 antibody can compete with anti-IL-17 antibody for binding to IL-17). A conservative substitution of an amino acid, i.e., replacing an amino acid with a different amino acid of similar properties (e.g., hydrophilicity and degree and distribution of charged regions) is recognized in the art as typically involving a minor change. These minor changes can be identified, in part, by considering the hydropathic index of amino acids, as understood in the art (see, e.g., Kyte et al. (1982) J. Mol. Biol. 157: 105-132). The hydropathic index of an amino acid is based on a consideration of its hydrophobicity and charge. It is known in the art that amino acids of similar hydropathic indexes in a protein can be substituted and the protein still retains protein function. In one aspect, amino acids having hydropathic indexes of ± 2 are substituted. The hydrophilicity of amino acids also can be used to reveal substitutions that would result in proteins retaining biological function. A consideration of the hydrophilicity of amino acids in the context of a peptide permits calculation of the greatest local average hydrophilicity of that peptide, a useful measure that has been reported to correlate well with antigenicity and immunogenicity (see, e.g., US Patent No. 4,554,101). Substitution of amino acids having similar hydrophilicity values can result in peptides retaining biological activity, for example immunogenicity, as is understood in the art. In one aspect, substitutions are performed with amino acids having hydrophilicity values within ± 2 of each other. Both the hydrophobicity index and the hydrophilicity value of amino acids are influenced by the particular side chain of that amino acid. Consistent with that observation, amino acid substitutions that are compatible with biological function are understood to depend on the relative similarity of the amino acids, and particularly the side chains of

those amino acids, as revealed by the hydrophobicity, hydrophilicity, charge, size, and other properties. The term "variant" also includes polypeptide or fragment thereof that has been differentially processed, such as by proteolysis, phosphorylation, or other post-translational modification, yet retains its biological activity or antigen reactivity, e.g., the ability to bind to IL-17. The term "variant" encompasses fragments of a variant unless otherwise defined. A variant may be about 99%, 98%, 97%, 96%, 95%, 94%, 93%, 92%, 91%, 90%, 89%, 88%, 87%, 86%, 85%, 84%, 83%, 82%, 81%, 80%, 79%, 78%, 77%, 76%, or 75% identical to the wildtype sequence.

Generation of binding proteins

[0150] Binding proteins capable of binding IL-1 β and/or IL-17 and methods of making the same are provided. The binding protein can be generated using various techniques. Expression vectors, host cell and methods of generating the binding protein are provided and others are known in the art.

A. Construction of binding protein molecules

[0151] The binding protein may be designed such that two different light chain variable domains (VL) from the two different parent monoclonal antibodies are linked in tandem directly or via a linker by recombinant DNA techniques, followed by the light chain constant domain CL. Similarly, the heavy chain comprises two different heavy chain variable domains (VH) linked in tandem, directly or via a linker, followed by the constant domain CH1 and Fc region (Figure 1).

[0152] The variable domains can be obtained using recombinant DNA techniques from parent antibodies generated by any one of the methods described herein.

[0153] The linker sequence may be a single amino acid or a polypeptide sequence. In an embodiment, the choice of linker sequences is based on crystal structure analysis of several Fab molecules. There is a natural flexible linkage between the variable domain and the CH1/CL constant domain in Fab or antibody molecular structure. This natural linkage comprises approximately 10-12 amino acid residues, contributed by 4-6 residues from the C-terminus of a V domain and 4-6 residues from the N-terminus of a CL/CH1 domain. DVD-Ig binding proteins were generated using N-terminal 5-6 amino acid residues, or 11-12 amino acid residues, of CL or CH1 as a linker in the light chain and heavy chains, respectively. The N-terminal residues of CL or CH1 domains, particularly the first 5-6 amino acid residues, can adopt a loop conformation without strong secondary structures, and therefore can act

as flexible linkers between the two variable domains. The N-terminal residues of CL or CH1 domains are natural extension of the variable domains, as they are part of the Ig sequences, and therefore their use minimizes to a large extent any immunogenicity potentially arising from the linkers and junctions.

[0154] In a further embodiment, the binding protein includes at least one X1 linker selected from AKTTPKLEEGEFSEAR (SEQ ID NO: 1); AKTTPKLEEGEFSEARV (SEQ ID NO: 2); AKTTPKLGG (SEQ ID NO: 3); SAKTTPKLGG (SEQ ID NO: 4); SAKTTP (SEQ ID NO: 5); RADAAP (SEQ ID NO: 6); RADAAPTVS (SEQ ID NO: 7); RADAAAAGGPGS (SEQ ID NO: 8); RADAAAA(G₄S)₄ (SEQ ID NO: 9); SAKTTPKLEEGEFSEARV (SEQ ID NO: 10); ADAAP (SEQ ID NO: 11); ADAAPTVSIFPP (SEQ ID NO: 12); TVAAP (SEQ ID NO: 13); TVAAPSVFIFPP (SEQ ID NO: 14); QPKAAP (SEQ ID NO: 15); QPKAAPSVTLFPP (SEQ ID NO: 16); AKTTPP (SEQ ID NO: 17); AKTTPPSVTPLAP (SEQ ID NO: 18); AKTTAP (SEQ ID NO: 19); AKTTAPSVYPLAP (SEQ ID NO: 20); ASTKGP (SEQ ID NO: 21); ASTKGPSVFPLAP (SEQ ID NO: 22); GGGGSGGGGSGGGGS (SEQ ID NO: 23); GENKVEYAPALMALS (SEQ ID NO: 24); GPAKELTPLKEAKVS (SEQ ID NO: 25); or GHEAAVMQVQYPAS (SEQ ID NO: 26); TVAAPSVFIFPPTVAAPSVFIFPP (SEQ ID NO: 27); ASTKGPSVFPLAPASTKGPSVFPLAP (SEQ ID NO: 28); GGGGSGGGGS (SEQ ID NO: 29); GGSGGGGSG (SEQ ID NO: 30); and G/S based sequences (e.g., G4S and G4S repeats; SEQ ID NO: 31). In an embodiment, X1 on one polypeptide chain of a binding protein comprises SEQ ID NO: 29 and X1 on the other polypeptide chain comprises SEQ ID NO: 30. In an embodiment, X2 is an Fc region. In another embodiment, X2 is a variant Fc region.

[0155] Other linker sequences may include any sequence of any length of a CL/CH1 domain but not all residues of a CL/CH1 domain; for example the first 5-12 amino acid residues of a CL/CH1 domain; the light chain linkers can be from C κ or C λ ; and the heavy chain linkers can be derived from CH1 of any isotype, including C γ 1, C γ 2, C γ 3, C γ 4, C α 1, C α 2, C δ , C ϵ , and C μ . Linker sequences may also be derived from other proteins such as Ig-like proteins (e.g., TCR, FcR, KIR); G/S based sequences (e.g., G4S repeats; SEQ ID NO: 31); hinge region-derived sequences; and other natural sequences from other proteins.

[0156] In an embodiment, a constant domain is linked to the two linked variable domains using recombinant DNA techniques. In an embodiment, a sequence comprising linked heavy chain variable domains is linked to a heavy chain constant domain and a sequence comprising linked light chain variable domains is linked to a

light chain constant domain. In an embodiment, the constant domains are human heavy chain constant domains and human light chain constant domains respectively. In an embodiment, the DVD heavy chain is further linked to an Fc region. The Fc region may be a native sequence Fc region or a variant Fc region. In another embodiment, the Fc region is a human Fc region. In another embodiment, the Fc region includes Fc region from IgG1, IgG2, IgG3, IgG4, IgA, IgM, IgE, or IgD.

[0157] In an embodiment, an antibody or functional antigen binding fragment thereof is disclosed, comprising an antibody having a functional binding site capable of binding IL-1beta or IL-17 and having a variable region comprising paired VH and VL sequences selected from the pairs listed in Table 1, or comprising the CDR regions of those VH and VL regions. For instance, the antibody or functional antigen binding fragment thereof may be capable of binding IL-1beta and have a variable region comprising SEQ ID NOs: 32 and 33. Likewise, an antibody or functional antigen binding fragment thereof can be capable of binding IL-17 and have a variable region comprising, e.g., SEQ ID NOs: 44 and 45 or SEQ ID NOs: 46 and 47. Similar antibodies are disclosed comprising the remaining pairs in Table 1. In an embodiment, a functional antigen binding fragment of an antibody described above is disclosed, wherein the antigen binding fragment retains variable sequences sufficient to form a binding site capable of binding the target antigen. For example, the antigen binding fragment may comprise the CDR regions taken from the paired VH and VL sequences in Table 1, or the full VH and VL sequences with or without an Fc domain. A functional antigen binding fragment may include, among other examples, a humanized, fully human, camelized, single-chain, chimeric, synthetic, recombinant, hybrid, mutated, back-mutated, or CDR-grafted antibody, or a Fab, F(ab')₂, Fv, scFv, Fd, dAb fragment, a VHH (also referred to as a nanobody), or any other antibody fragment that retains antigen-binding function, including bi-specific or multi-specific antibodies.

[0158] In an embodiment, a binding protein (e.g., a dual variable domain binding protein) is disclosed comprising variable domains selected from those in Table 1. In some embodiments, the binding protein comprises first and second polypeptide chains, each of which comprises VD1-(X1)_n-VD2-C-X2, and wherein the first and second chains of the binding protein together form two functional binding sites, wherein those binding sites are capable of binding IL-1beta and/or IL-17. In some embodiments, the VD1 and VD2 sequences are independently chosen (i.e., the choice of VH and VL sequences for the VD1 position does not impact the choice of

sequences for the VD2 position, and vice versa). In an embodiment, each functional binding site comprises paired VH and VL sequences selected from the pairs listed in Table 1 (e.g., the paired VH and VL sequences of SEQ ID NO: 32 and 33, forming a binding site for IL-1beta), or comprising the CDR regions of those VH and VL sequences. In some embodiments, the first chain comprises a first VH sequence at position VD1 and a second VH sequence at position VD2, both of which are selected from Table 1, or the VD1 and VD2 domains contain the CDR sequences from those selected VH sequences, while the second chain comprises a first VL sequence at position VD1 and a second VL sequence at position VD2, both of which are selected from Table 1, or the VD1 and VD2 domains contain the CDR sequences from those selected VL sequences. In other embodiments, the VH-VL arrangement of the first or second binding site is flipped across the two polypeptide chains, such that each chain comprises a VH sequence joined to a VL sequence, while the two chains together still form two functional binding sites. For instance, the first polypeptide chain may comprise a VH sequence at the VD1 position and a VL sequence at the VD2 position, while the second chain would comprise the paired VL sequence at the VD1 position (forming a first functional binding site) and the paired VH sequence at the VD2 position (forming a second binding site).

[0159] In an embodiment, two first chain polypeptides and two second chain polypeptides are combined to form a DVD-Ig binding protein having two arms and four binding sites. An example of a DVD-Ig binding protein structure having two arms and four binding sites is shown in Figure 1. In an embodiment, a DVD-Ig binding protein comprises at the VD1 and VD2 positions on each arm at least one, or at least two, at least three, or at least four, of the VH and VL sequence pairs listed in Table 1, in any orientation. In some embodiments, sequence pairs forming the binding sites are independently chosen (e.g., the choice of VH and VL sequences for the VD1 position on one arm does not impact the choice of sequences for the VD1 position on the other arm, nor does it affect the choice of sequences for the VD2 positions on either arm). The VH and VL sequences provided in Table 1 below comprise complementarity determining regions (CDRs) and framework sequences. In some embodiments, one or more of the framework sequences are replaced, without loss of function, by other framework sequences, e.g., from binding proteins that are known in the art to bind to the same antigen.

[0160] In another embodiment, two heavy chain DVD-Ig polypeptides and two light chain DVD-Ig polypeptides are combined to form a DVD-Ig binding protein.

Tables 1A-1C list amino acid sequences of VH and VL regions of exemplary antibodies useful for treating disease. In an embodiment, a DVD-Ig comprising at least two of the VH and/or VL regions listed in Table 1, in any orientation, is provided. In some embodiments, VD1 and VD2 are independently chosen. Therefore, in some embodiments, VD1 and VD2 comprise the same SEQ ID NO and, in other embodiments, VD1 and VD2 comprise different SEQ ID NOS. The VH and VL domain sequences provided below comprise complementarity determining regions (CDRs) and framework sequences that are either known in the art or readily discernible using methods known in the art. In some embodiments, one or more of these CDRs and/or framework sequences are replaced, without loss of function, by other CDRs and/or framework sequences from binding proteins that are known in the art to bind to the same antigen.

Table 1: List of Amino Acid Sequences of VH and VL Regions of Antibodies for Generating Binding Proteins, Including Multivalent Binding Proteins

SEQ ID No.	ABT Unique ID	Protein region	Sequence 1234567890123456789012345678901234567890
32	AB268VH	VH-IL1b (seq 1)	EVQLVESGGGVVQPGRSLRLSCSA3GFI FSR YDMSWVRQA PGKGLEWVAYIISHGGAGTYYPDSVKGRFTISRDN SKNTLF LQMDSLRPEDTGVYFCARGGVTKGYFDVWGQGTPTVTVSS
33	AB268VL	VL-IL1b (seq 1)	DIQMTQSPSSLSASVGDRVTITCRASGNIHNYLTWYQQTP GKAPKLLIYN AKTLADGVPSRFSGSGSGTDYTF TISSLP EDIATYYCQRFWSIPYTFGQGTKLQITR
34	AB269VH	VH-IL1b (seq 2)	EVQLVESGGGVVQPGRSLRLSCSA3GFI FSR YDMSWVRQA PGKGLEWVAYIISHGGAGTYYPDSVKGRFTISRDN SKNTLF LQMDSLRAEDTAVYYCARGGVYKGYFDVWGQGTPTVTVSS
35	AB269VL	VL-IL1b (seq 2)	DIQMTQSPSSLSASVGDRVTITCRASGNIHNYLTWYQQTP GKAPKLLIYN AKTLADGVPSRFSGSGSGTDYTF TISSLP EDIATYYCQRFWSIPYTFGQGTKLQITR
36	AB270VH	VH-IL1b (seq 3)	EVQLQESGGFGLVKPSETLSLTCTVSGFSLSDYGVSWIRQP PGKGLEWLGLIWGGGDTYYNSPLKSRLTISKDN SKSQVSL KLSSVTAADTAVYYCAKQRTLWGYDLYGMDYWGQGT LVTV SS
37	AB270VL	VL-IL1b (seq 3)	DTQVTQSPSSLSASVGDRVTITCITSTDIDVDMN WYQQKP GKFPKLLISQGNLTPGVPSRFSSSGSGTDFTFT ISSLP EDFATYYCLQSDNLEPLTFCGQGTKLEIKR
38	AB271VH	VH-IL1b (seq 4)	EVQLQESGGFGLVKPSETLSLTCTVSGFSLSDYGVSWIRQP PGKGLEWLGLIWGGGDTYYNSPLKSRLTISKDN SKSQVSL KLSSVTAADTAVYYCAKQRTLWGYDLYGMDYWGQGT LVTV SS
39	AB271VL	VL-IL1b (seq 4)	DTVVTQSPAFLSVTFGEKVTITCITSTDIDVDMN WYQQKP DQPPKLLISQGNLTPGVPSRFSSSGSGTDFTFT ISSLEA EDAATYYCLQSDNLEPLTFCGQGTKLEIKR
40	AB272VH	VH-IL1b (seq 5)	EVQLVESGGGLVQP GGSRLRLSCAVSGFTLS DYGVSWIRQA PGKGLEWLGLIWGGGDTYYNSPLKSRLTISKDN SKSTVYL QMNSLRAEDTAVYYCAKQRTLWGYDLYGMDYWGQGT LVTV SS

SEQ ID No.	ABT Unique ID	Protein region	Sequence 1234567890123456789012345678901234567890
41	AB272VL	VL-IL1b (seq 5)	ETTVTQSPSSLSASVGDRTITCITSTDDIDVDMNWFYQQKP GKPPKLLISQGNLRFPGVPSRFSSSSGSGTDFTFTISSLP EDFATYYCQSDNLPITFGQGTKLEIKR
42	AB273VH	VH-IL17 (seq 1)	EVQLVQSGAEVKKPGSSVKVSCKASGYTFTDYEIHWVRQA PGQGLEWMGVNDPESGGTFYFNQKFDGRVTLTADESTSTAY MELSSLRSEDTAVYYCTRYSKWDSFDGMDYWGQGTITVTVS S
43	AB273VL	VL-IL17 (seq 1)	DIQMTQSPSSLSASVGDRTITCRASSGIISYIDWFYQQKP GKAPKRLIYATFDLASGVPSRFSSGSGTDYTLTISSLQP EDFATYYCQVGSYPETFGQGTKLEIKR
44	AB420VH	VH-IL17 (seq 2)	EVQLVQSGAEVKKPGSSVKVSCKASGGSGFGGYGIGWVRQA PGQGLEWMGGITPFFGFADYAKFQGRVTITADESTTTAY MELSGLTSDDTAVYYCARDPNEFWGGYYSTHDFDSWGQGT ITVTVSS
45	AB420VL	VL-IL17 (seq 2)	EIVLTQSPDFQSVPKPKVTITCRASQDIGSELHWYQQKP DQPPKLLIKYASHSTSGVPSRFSSGSGTDFTLTINGLEA EDAGTYYCHQTDSLPTFGPGTKVDIKR
46	AB461VH	VH-IL17 (seq 3)	EVQLVQSGAEVKKPGESVKISCKASGGSGFRSYGISWVRQA PGQGLEWMGGITPFFGITDYAKFQGRVTITADESTTTAY MELSGLTSDDTAVYYCAREPNDFWGGYYDTHDFDSWGQGT ITVTVSS
47	AB461VL	VL-IL17 (seq 3)	EIVLTQSPDFQSVPKPKVTITCRASQDIGSELHWYQQKP DQSPKLLIKYASHSTSGVPSRFSSGSGTDFTLTINGLEA EDAATYYCHQSDTLPTFGQGTKVDIKR
	AB274VH	VH-IL17 (seq 4)	EVQLVQSGAEVKKPGSSVKVSCKASGGSGFGGYGIGWVRQA PGQGLEWMGGITPFFGFADYAKFQGRVTITADESTTTAY MELSGLTSDDTAVYYCARDPNEFWNGYYSTHDFDSWGQGT ITVTVSS
	AB274VL	VL-IL-17 (seq 4)	EIVLTQSPDFQSVPKPKVTITCRASQDIGSELHWYQQKP DQPPKLLIKYASHSTSGVPSRFSSGSGTDFTLTINGLEA EDAGTYYCHQTDSLPTFGPGTKVDIKR

[0161] CDRs 1-3 of each VH and VL sequence listed in Table 1 are underlined. For instance, CDRs 1-3 are underlined for SEQ ID NO: 32 at amino acid positions 31-35, 50-66, and 99-108. Detailed descriptions of specific DVD-Ig binding proteins capable of binding specific targets, and methods of making the same, are provided throughout this disclosure, and in the Examples section below.

B. Production of binding proteins

[0162] The binding proteins provided herein may be produced by any of a number of techniques known in the art. For example, expression from host cells, wherein expression vector(s) encoding the DVD-Ig heavy and DVD-Ig light chains is (are) transfected into a host cell by standard techniques. Although it is possible to express the DVD-Ig binding proteins provided herein in either prokaryotic or eukaryotic host cells, DVD-Ig binding proteins are preferably expressed in eukaryotic cells, for example, mammalian host cells, because such eukaryotic cells (and in

particular mammalian cells) are more likely than prokaryotic cells to assemble and secrete a properly folded and immunologically active DVD-Ig binding protein.

[0163] In an exemplary system for recombinant expression of DVD-Ig proteins, a recombinant expression vector encoding both the DVD-Ig heavy chain and the DVD-Ig light chain is introduced into dhfr- CHO cells by calcium phosphate-mediated transfection. Within the recombinant expression vector, the DVD-Ig heavy and light chain sequences are each operatively linked to CMV enhancer/AdMLP promoter regulatory elements to drive high levels of transcription of the genes. The recombinant expression vector also carries a DHFR gene, which allows for selection of CHO cells that have been transfected with the vector using methotrexate selection/amplification. The selected transformant host cells are cultured to allow for expression of the DVD-Ig heavy and light chains and intact DVD-Ig protein is recovered from the culture medium. Standard molecular biology techniques are used to prepare the recombinant expression vector, transfect the host cells, select for transformants, culture the host cells and recover the DVD-Ig protein from the culture medium. A method of synthesizing a DVD-Ig protein provided herein by culturing a host cell provided herein in a suitable culture medium until a DVD-Ig protein is synthesized is also provided. The method can further comprise isolating the DVD-Ig protein from the culture medium.

[0164] An important feature of a DVD-Ig binding protein is that it can be produced and purified in a similar way to a conventional antibody. The production of DVD-Ig binding protein results in a homogeneous, single major product with desired dual-specific activity, without the need for sequence modification of the constant region or chemical modifications. Other previously described methods to generate "bi-specific", "multi-specific", and "multi-specific multivalent" full length binding proteins can lead to the intracellular or secreted production of a mixture of assembled inactive, mono-specific, multi-specific, multivalent, full length binding proteins, and multivalent full length binding proteins with a combination of different binding sites.

[0165] Surprisingly, the design of the "dual-specific multivalent full length binding proteins" provided herein leads to a dual variable domain light chain and a dual variable domain heavy chain that assemble primarily to the desired "dual-specific multivalent full length binding proteins".

[0166] In some embodiments, at least 50%, at least 75% and at least 90% of the assembled, and expressed dual variable domain immunoglobulin molecules are

the desired dual-specific tetravalent protein, and therefore possess enhanced commercial utility. Thus, in various embodiments a method to express a dual variable domain light chain and a dual variable domain heavy chain in a single cell leading to a single primary product of a “dual-specific tetravalent full length binding protein” is provided.

[0167] Methods of expressing a dual variable domain light chain and a dual variable domain heavy chain in a single cell leading to a “primary product” of a “dual-specific tetravalent full length binding protein”, where the “primary product” is more than 50%, such as more than 75% and more than 90%, of all assembled protein, comprising a dual variable domain light chain and a dual variable domain heavy chain are provided.

Uses of binding proteins

[0168] Given their ability to bind to two or more antigens, the binding proteins provided herein can be used to detect the antigens (e.g., in a biological sample, such as serum or plasma), using a conventional immunoassay, such as an enzyme linked immunosorbent assays (ELISA), a radioimmunoassay (RIA), or tissue immunohistochemistry. The binding protein is directly or indirectly labeled with a detectable substance to facilitate detection of the bound or unbound antibody. Suitable detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials and radioactive materials. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β -galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin. An example of a luminescent material is luminol and examples of suitable radioactive materials include ^3H , ^{14}C , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I , ^{177}Lu , ^{166}Ho , and ^{153}Sm .

[0169] In an embodiment, the binding proteins provided herein are capable of neutralizing the activity of their antigen targets both *in vitro* and *in vivo*. Accordingly, such binding proteins can be used to inhibit antigen activity, e.g., in a cell culture containing the antigens, in human subjects or in other mammalian subjects having the antigens with which a binding protein provided herein cross-reacts. In another embodiment, a method for reducing antigen activity in a subject suffering from a disease or disorder in which the antigen activity is detrimental is provided. A binding

protein provided herein can be administered to a human subject for therapeutic purposes.

[0170] The term “a disorder in which antigen activity is detrimental” is intended to include diseases and other disorders in which the presence of the antigen in a subject suffering from the disorder has been shown to be or is suspected of being either responsible for the pathophysiology of the disorder or a factor that contributes to a worsening of the disorder. Accordingly, a disorder in which antigen activity is detrimental is a disorder in which reduction of antigen activity is expected to alleviate the symptoms and/or progression of the disorder. Such disorders may be evidenced, for example, by an increase in the concentration of the antigen in a biological fluid of a subject suffering from the disorder (e.g., an increase in the concentration of antigen in serum, plasma, synovial fluid, etc., of the subject). Non-limiting examples of disorders that can be treated with the binding proteins provided herein include those disorders discussed below and in the section pertaining to pharmaceutical compositions comprising the binding proteins.

[0171] DVD-Ig binding proteins are useful as therapeutic agents to simultaneously block two different targets to enhance efficacy/safety and/or increase patient coverage.

[0172] Additionally, DVD-Ig binding proteins provided herein can be employed for tissue-specific delivery (target a tissue marker and a disease mediator for enhanced local PK thus higher efficacy and/or lower toxicity), including intracellular delivery (targeting an internalizing receptor and an intracellular molecule), delivering to inside brain (targeting transferrin receptor and a CNS disease mediator for crossing the blood-brain barrier). DVD-Ig binding protein can also serve as a carrier protein to deliver an antigen to a specific location via binding to a non-neutralizing epitope of that antigen and also to increase the half-life of the antigen. Furthermore, DVD-Ig binding protein can be designed to either be physically linked to medical devices implanted into patients or target these medical devices (see Burke et al. (2006) *Advanced Drug Deliv. Rev.* 58(3): 437-446; Hildebrand et al. (2006) *Surface and Coatings Technol.* 200(22-23): 6318-6324; Drug/ device combinations for local drug therapies and infection prophylaxis, Wu (2006) *Biomaterials* 27(11):2450-2467; Mediation of the cytokine network in the implantation of orthopedic devices, Marques (2005) *Biodegradable Systems in Tissue Engineer. Regen. Med.* 377-397). Briefly, directing appropriate types of cell to the site of medical implant may promote healing and restoring normal tissue function. Alternatively, inhibition of mediators (including

but not limited to cytokines), released upon device implantation by a DVD coupled to or target to a device is also provided.

C. Use of binding proteins in various diseases

[0173] Binding protein molecules provided herein are useful as therapeutic molecules to treat various diseases, e.g., wherein the targets that are recognized by the binding proteins are detrimental. Such binding proteins may bind one or more targets involved in a specific disease. Inhibition of IL-1 β and/or IL-17 has also been shown to enhance anti-viral vaccines in animal models and may be beneficial in the treatment of HIV and other infectious diseases, for example, the human rhinovirus, other enteroviruses, coronavirus, herpes viruses, influenza virus, parainfluenza virus, respiratory syncytial virus or adenovirus.

[0174] Without limiting the disclosure, further information on certain disease conditions is provided.

1. Human autoimmune and inflammatory response

[0175] IL-1 β and/or IL-17 have been implicated in general autoimmune and inflammatory responses, including, for example, asthma, allergies, allergic lung disease, allergic rhinitis, atopic dermatitis, chronic obstructive pulmonary disease (COPD), fibrosis, cystic fibrosis (CF), fibrotic lung disease, idiopathic pulmonary fibrosis, liver fibrosis, lupus, hepatitis B-related liver diseases and fibrosis, sepsis, systemic lupus erythematosus (SLE), glomerulonephritis, inflammatory skin diseases, psoriasis, diabetes, insulin dependent diabetes mellitus, inflammatory bowel disease (IBD), ulcerative colitis (UC), Crohn's disease (CD), rheumatoid arthritis (RA), osteoarthritis (OA), multiple sclerosis (MS), graft-versus-host disease (GVHD), transplant rejection, ischemic heart disease (IHD), celiac disease, contact hypersensitivity, alcoholic liver disease, Behcet's disease, atherosclerotic vascular disease, ocular surface inflammatory diseases, or Lyme disease. Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat these conditions.

[0176] The binding proteins provided herein can also be used to treat neurological disorders. In an embodiment, the binding proteins provided herein or antigen-binding portions thereof, are used to treat neurodegenerative diseases, and conditions involving neuronal regeneration and spinal cord injury.

2. Asthma

[0177] Allergic asthma is characterized by the presence of eosinophilia, goblet cell metaplasia, epithelial cell alterations, airway hyperreactivity (AHR), and Th2 and Th1 cytokine expression, as well as elevated serum IgE levels. Corticosteroids are the most important anti-inflammatory treatment for asthma today, however their mechanism of action is non-specific and safety concerns exist, especially in the juvenile patient population. The development of more specific and targeted therapies is therefore warranted.

[0178] IL-1 β has been implicated as having a pivotal role in causing pathological responses associated with asthma. The development of anti-IL-1 β mAb therapy to reduce the effects of IL-1 β in the lung is an exciting new approach that offers considerable promise as a novel treatment for asthma. However other mediators of differential immunological pathways are also involved in asthma pathogenesis, and blocking these mediators, in addition to IL-1 β , may offer additional therapeutic benefit. Such target pairs include, but are not limited to, IL-1 β and a pro-inflammatory cytokine, such as IL-17. There is growing evidence that IL-17 is involved in the pathogenesis of asthma. IL-17 induces the neutrophils into the airways and also enhances T-helper 2 (Th2) cell-mediated eosinophilic airway inflammation in asthma. Recent studies have demonstrated that inhibitors and other diverse regulators of IL-17 reduce antigen-induced airway inflammation, bronchial hyperresponsiveness, and Th2 cytokine levels in animal models of asthma (for a review see Park and Lee (2010) *Respiratory Res.*, 11:78). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat asthma.

[0179] Animal models such as an OVA-induced asthma mouse model, where both inflammation and AHR can be assessed, are known in the art and may be used to determine the ability of various binding protein molecules to treat asthma. Animal models for studying asthma are disclosed in Coffman, et al. (2005) *J. Exp. Med.* 201(12):1875-1879; Lloyd et al. (2001) *Adv. Immunol.* 77: 263-295; Boyce et al. (2005) *J. Exp. Med.* 201(12):1869-1873; and Snibson et al. (2005) *J. Brit. Soc. Allergy Clin. Immunol.* 35(2):146-52. In addition to routine safety assessments of these target pairs specific tests for the degree of immunosuppression may be warranted and helpful in selecting the best target pairs (see Luster et al. (1994) *Toxicol.* 92(1-3):229-43; Descotes et al. (1992) *Dev. Biol. Standard.* 77:99-102; Hart et al. (2001) *J. Allergy Clin. Immunol.* 108(2):250-257).

3. Rheumatoid arthritis

[0180] Rheumatoid arthritis (RA), a systemic disease, is characterized by a chronic inflammatory reaction in the synovium of joints and is associated with degeneration of cartilage and erosion of juxta-articular bone. Many pro-inflammatory cytokines, chemokines, and growth factors are expressed in diseased joints. Recent studies indicate that the involvement of T cells in RA is mediated to a significant extent by IL-17. Animal studies have shown that markedly increased IL-17 expression was detected in mice that develop articular lesions resembling human RA. Beneficial effects of IL-17 blockade were also observed various animal models of the disease (for a review see Witowski et al. (2004) *Cell. Mol. Life Sci.* 61: 567–579). Whether a binding protein molecule will be useful for the treatment of rheumatoid arthritis can be assessed using pre-clinical animal RA models such as the collagen-induced arthritis mouse model. Other useful models are also well known in the art (see Brand (2005) *Comp. Med.* 55(2):114-22). Based on the cross-reactivity of the parental antibodies for human and mouse orthologues (e.g., reactivity for human and mouse TNF, human and mouse IL-15, etc.) validation studies in the mouse CIA model may be conducted with “matched surrogate antibody” derived binding protein molecules; briefly, a binding protein based on two (or more) mouse target specific antibodies may be matched to the extent possible to the characteristics of the parental human or humanized antibodies used for human binding protein construction (e.g., similar affinity, similar neutralization potency, similar half-life, etc.). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat rheumatoid arthritis.

4. Osteoarthritis

[0181] The initiation, maintenance, and progression of OA is mediated by a complex cascade of mechanical and biochemical pathways in which IL-1 plays a pivotal role. IL-1 α and IL-1 β are produced not only by monocytes, macrophages, and neutrophils, but by cells in joint tissues, such as chondrocytes, synovial fibroblasts, and osteoclasts (see, e.g., Dinarello et al. (2009) *Ann. Rev. Immunol.* 27: 519-550). In vitro, IL-1 can stimulate chondrocytes and synoviocytes to produce proteinases involved in cartilage destruction leading to OA (see, e.g., Dayer et al. (1977) *Science* 195: 181-183; Dayer et al. (1984) *Biochem. Pharmacol.* 33: 2893-2899; McGuire-Goldring et al. (1984) *Arthritis Rheum.* 27: 654-662), as well as inhibit synthesis of proteoglycan and collagen type II, the main components of the extracellular matrix (ECM) of normal hyaline cartilage (see, e.g., Goldring et al. (1987) *J. Biol. Chem.* 262: 16724-16729; Goldring et al. (1988) *J. Clin. Investig.* 82: 2026-2037). Preclinical and

clinical studies have provided further evidence of IL-1 in the pathogenesis of OA. For example, intra-articular (ia) injection of IL-1 into animal knees resulted in leukocyte infiltration and cartilage loss (Pettiphar et al. (1986) *Proc. Natl. Acad. Sci. USA* 83: 8749-8753). In contrast, ia injection of IL-1 antagonist resulted in significant reduction in the progression of experimental OA (see, e.g., Pelletier et al. (1997) *Arthritis Rheum.* 40: 1012-1019; Caron et al. (1996) *Arthritis Rheum.* 39: 1535-1544); Fernandes et al. (1999) *Am. J. Pathol.* 154: 11590-11690); Zhang et al. (2006) *Biochem. Biophys. Res. Commun.* 341: 202-208). In addition, IL-1 knockout (KO) mice were found to be resistant to surgically induced cartilage damage when compared to their wild-type counterparts (Glasson et al. (2009) *Osteoarthritis Cartilage*, 18: 572-580).

[0182] Both IL-1 α and IL-1 β are expressed in synovial membranes, cartilage, and synovial fluid of human OA patients (see, e.g., Farahat et al. (1993) *Ann. Rheum. Dis.* 52: 870-875). The IL-1 antagonist, Anakinra, which is an IL-1 receptor antagonist, and AMG-108, which is an IL-1 receptor monoclonal antibody, have demonstrated some efficacy in OA trials with respect to symptoms and chondroprotection ("Results from a Randomized Controlled Trial of AMG 108 (a fully human monoclonal antibody to IL-1R type I) in Patients With Osteoarthritis of the Knee" Cohen et al., ACR2007). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat osteoarthritis.

5. Systemic lupus erythematosus (SLE)

[0183] The immunopathogenic hallmark of SLE is the polyclonal B cell activation, which leads to hyperglobulinemia, autoantibody production and immune complex formation. Significant increased levels of IL-17 have been detected in patients with systemic lupus erythematosus (Morimoto et al. (2001) *Autoimmunity*, 34(1):19-25; Wong et al. (2008) *Clin Immunol.* 127(3):385-93). IL-17 represents an important cytokine in the pathogenesis of SLE. Increased IL-17 production has been shown in patients with SLE as well as in animals with lupus-like diseases. Animal models have demonstrated that blockade of IL-17 decreases lupus manifestations (for a review see Nalbandian et al. (2009) 157(2): 209–215). Based on the cross-reactivity of the parental antibodies for human and mouse orthologues (e.g., reactivity for human and mouse CD20, human and mouse interferon alpha, etc.) validation studies in a mouse lupus model may be conducted with "matched surrogate antibody" derived binding protein molecules. Briefly, a binding protein based two (or more) mouse target specific antibodies may be matched to the extent possible to the characteristics of the

parental human or humanized antibodies used for human binding protein construction (e.g., similar affinity, similar neutralization potency, similar half-life, etc.). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat SLE.

6. Multiple sclerosis

[0184] Multiple sclerosis (MS) is a complex human autoimmune-type disease with a predominantly unknown etiology. Immunologic destruction of myelin basic protein (MBP) throughout the nervous system is the major pathology of multiple sclerosis. Of major consideration are immunological mechanisms that contribute to the development of autoimmunity. In particular, antigen expression, cytokine and leukocyte interactions, and regulatory T-cells, which help balance/modulate other T-cells such as Th1 and Th2 cells, are important areas for therapeutic target identification. In MS, increased expression of IL-17 has been detected both in brain lesions and in mononuclear cells isolated from blood and cerebrospinal fluid. IL-17-producing cells are extremely enriched in active MS lesions, suggesting that neutralization of this cytokine has the potential of being beneficial (for a review see Witowski et al. (2004) *Cell. Mol. Life Sci.* 61: 567–579). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat MS.

[0185] Several animal models for assessing the usefulness of the binding proteins to treat MS are known in the art (see Steinman et al. (2005) *Trends Immunol.* 26(11):565-71; Lublin et al. (1985) *Springer Semin. Immunopathol.* 8(3):197-208; Genain et al. (1997) *J. Mol. Med.* 75(3):187-97; Tuohy et al. (1999) *J. Exp. Med.* 189(7):1033-42; Owens et al. (1995) *Neurol. Clin.* 13(1):51-73; and Hart et al. (2005) *J. Immunol.* 175(7):4761-8.) Based on the cross-reactivity of the parental antibodies for human and animal species orthologues validation studies in the mouse EAE model may be conducted with "matched surrogate antibody" derived binding protein molecules. Briefly, a binding protein based on two (or more) mouse target specific antibodies may be matched to the extent possible to the characteristics of the parental human or humanized antibodies used for human binding protein construction (e.g., similar affinity, similar neutralization potency, similar half-life, etc.). The same concept applies to animal models in other non-rodent species, where a "matched surrogate antibody" derived binding protein would be selected for the anticipated pharmacology and possibly safety studies. In addition to routine safety assessments of these target pairs specific tests for the degree of immunosuppression may be warranted and helpful in selecting the best target pairs (see Luster et al. (1994) *Toxicol.* 92(1-3): 229-

43; Descotes et al. (1992) *Devel. Biol. Standard.* 77: 99-102; Jones (2000) *IDrugs* 3(4):442-6).

7. Sepsis

[0186] Overwhelming inflammatory and immune responses are essential features of septic shock and play a central part in the pathogenesis of tissue damage, multiple organ failure, and death induced by sepsis. Cytokines have been shown to be mediators of septic shock. These cytokines have a direct toxic effect on tissues; they also activate phospholipase A2. These and other effects lead to increased concentrations of platelet-activating factor, promotion of nitric oxide synthase activity, promotion of tissue infiltration by neutrophils, and promotion of neutrophil activity. IL-17 levels and clinical prognosis of sepsis have been shown to be negatively correlated. Neutralization of IL-17A can significantly improve the survival rate of patients with sepsis (see Flierl et al. (2008) *FASEB J.* 22: 2198-2205).

[0187] One embodiment pertains to binding proteins capable of binding one or more targets involved in sepsis, such as, for example IL-1 β and IL-17. The efficacy of such binding proteins for treating sepsis can be assessed in preclinical animal models known in the art (see Buras et al. (2005) *Nat. Rev. Drug Discov.* 4(10):854-65 and Calandra et al. (2000) *Nat. Med.* 6(2):164-70). Accordingly, in some embodiments the binding proteins disclosed herein can be used to treat sepsis.

8. Neurological disorders

a. Neurodegenerative diseases

[0188] Neurodegenerative diseases are either chronic in which case they are usually age-dependent or acute (e.g., stroke, traumatic brain injury, spinal cord injury, etc.). They are characterized by progressive loss of neuronal functions (e.g., neuronal cell death, axon loss, neuritic dystrophy, demyelination), loss of mobility and loss of memory. These chronic neurodegenerative diseases represent a complex interaction between multiple cell types and mediators. Treatment strategies for such diseases are limited and mostly constitute either blocking inflammatory processes with non-specific anti-inflammatory agents (e.g., corticosteroids, COX inhibitors) or agents to prevent neuron loss and/or synaptic functions. These treatments fail to stop disease progression. Specific therapies targeting more than one disease mediator may provide even better therapeutic efficacy for chronic neurodegenerative diseases than observed with targeting a single disease mechanism (see Deane et al. (2003) *Nature Med.* 9:907-13; and Masliah et al. (2005) *Neuron.* 46:857).

[0189] The binding protein molecules provided herein can bind one or more targets involved in chronic neurodegenerative diseases such as Alzheimers. The efficacy of binding protein molecules can be validated in pre-clinical animal models such as the transgenic mice that over-express amyloid precursor protein or RAGE and develop Alzheimer's disease-like symptoms. In addition, binding protein molecules can be constructed and tested for efficacy in the animal models and the best therapeutic binding protein can be selected for testing in human patients. Binding protein molecules can also be employed for treatment of other neurodegenerative diseases such as Parkinson's disease.

b. Neuronal regeneration and spinal cord injury

[0190] Despite an increase in knowledge of the pathologic mechanisms, spinal cord injury (SCI) is still a devastating condition and represents a medical indication characterized by a high medical need. Most spinal cord injuries are contusion or compression injuries and the primary injury is usually followed by secondary injury mechanisms (inflammatory mediators e.g., cytokines and chemokines) that worsen the initial injury and result in significant enlargement of the lesion area, sometimes more than 10-fold. IL-17 is a mediator of secondary degeneration, which contributes to neuroinflammation and hinders functional recovery. Studies using IL-17 KO mice have demonstrated that IL-17 contributes to neuroinflammatory responses and pain hypersensitivity following neuropathic injury (Kim and Moalem-Taylor (2010) J Pain. 12(3):370-83). IL-17 deficiency improves locomotor recovery and tissue sparing after spinal cord contusion injury in mice (Hill et al. (2011) Neurosci Lett. 487(3):363-7). Accordingly, in some embodiments the binding proteins disclosed herein can be used for neuronal regeneration and spinal cord repair.

[0191] The efficacy of binding protein molecules can be validated in pre-clinical animal models of spinal cord injury. In addition, these binding protein molecules can be constructed and tested for efficacy in the animal models and the best therapeutic binding protein can be selected for testing in human patients. In general, antibodies do not cross the blood brain barrier (BBB) in an efficient and relevant manner. However, in certain neurologic diseases, e.g., stroke, traumatic brain injury, multiple sclerosis, etc., the BBB may be compromised and allows for increased penetration of binding proteins and antibodies into the brain. In other neurological conditions, where BBB leakage is not occurring, one may employ the targeting of endogenous transport systems, including carrier-mediated transporters

such as glucose and amino acid carriers and receptor-mediated transcytosis-mediating cell structures/receptors at the vascular endothelium of the BBB, thus enabling trans-BBB transport of the binding protein. Structures at the BBB enabling such transport include but are not limited to the insulin receptor, transferrin receptor, LRP and RAGE. In addition, strategies enable the use of binding proteins also as shuttles to transport potential drugs into the CNS including low molecular weight drugs, nanoparticles and nucleic acids (Coloma et al. (2000) *Pharm Res.* 17(3):266-74; Boado et al. (2007) *Bioconjug. Chem.* 18(2):447-55).

9. Oncological disorders

[0192] Monoclonal antibody therapy has emerged as an important therapeutic modality for cancer (von Mehren et al. (2003) *Annu. Rev. Med.* 54:343-69). The use of dual-specific antibody that targets two separate tumor mediators will likely give additional benefit compared to a mono-specific therapy. IL-17 has been suggested to support tumor growth, probably by stimulating angiogenesis. IL-1 β also plays an important role in the regulation of anti-tumor immunity and tumor growth.

[0193] In an embodiment, diseases that can be treated or diagnosed with the compositions and methods provided herein include, but are not limited to, primary and metastatic cancers, including carcinomas of breast, colon, rectum, lung, oropharynx, hypopharynx, esophagus, stomach, pancreas, liver, gallbladder and bile ducts, small intestine, urinary tract (including kidney, bladder and urothelium), female genital tract (including cervix, uterus, and ovaries as well as choriocarcinoma and gestational trophoblastic disease), male genital tract (including prostate, seminal vesicles, testes and germ cell tumors), endocrine glands (including the thyroid, adrenal, and pituitary glands), and skin, as well as hemangiomas, melanomas, sarcomas (including those arising from bone and soft tissues as well as Kaposi's sarcoma), tumors of the brain, nerves, eyes, and meninges (including astrocytomas, gliomas, glioblastomas, retinoblastomas, neuromas, neuroblastomas, Schwannomas, and meningiomas), solid tumors arising from hematopoietic malignancies such as leukemias, and lymphomas (both Hodgkin's and non-Hodgkin's lymphomas).

[0194] In an embodiment, the antibodies and binding proteins provided herein or antigen-binding portions thereof, are used to treat cancer or in the prevention of metastases from the tumors described herein either when used alone or in combination with radiotherapy and/or other chemotherapeutic agents.

10. Gene therapy

[0195] In a specific embodiment, nucleic acid sequences encoding a binding protein provided herein or another prophylactic or therapeutic agent provided herein are administered to treat, prevent, manage, or ameliorate a disorder or one or more symptoms thereof by way of gene therapy. Gene therapy refers to therapy performed by the administration to a subject of an expressed or expressible nucleic acid. In this embodiment, the nucleic acids produce their encoded antibody or prophylactic or therapeutic agent provided herein that mediates a prophylactic or therapeutic effect.

[0196] Any of the methods for gene therapy available in the art can be used in the methods provided herein. For general reviews of the methods of gene therapy, see Goldspiel et al. (1993) Clin. Pharmacy 12:488-505; Wu and Wu (1991) Biotherapy 3:87-95; Tolstoshev (1993) Ann. Rev. Pharmacol. Toxicol. 32:573-596; Mulligan (1993) Science 260:926- 932; Morgan and Anderson (1993) Ann. Rev. Biochem. 62:191-217; and May (1993) TIBTECH 11(5):155-215. Methods commonly known in the art of recombinant DNA technology which can be used are described in Ausubel et al. (eds.), Current Protocols in Molecular Biology, John Wiley & Sons, NY (1993); and Kriegler, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY (1990). Detailed description of various methods of gene therapy are disclosed in US Patent Publication No. US20050042664.

Pharmaceutical Compositions

[0197] In various embodiments, pharmaceutical compositions comprising one or more binding proteins, either alone or in combination with prophylactic agents, therapeutic agents, and/or pharmaceutically acceptable carriers are provided. The pharmaceutical compositions comprising binding proteins provided herein are for use in, but not limited to, diagnosing, detecting, or monitoring a disorder, in preventing, treating, managing, or ameliorating a disorder or one or more symptoms thereof, and/or in research. The formulation of pharmaceutical compositions, either alone or in combination with prophylactic agents, therapeutic agents, and/or pharmaceutically acceptable carriers, are known to one skilled in the art (US Patent Publication No. 20090311253 A1).

[0198] Methods of administering a pharmaceutical composition or a prophylactic or therapeutic agent provided herein include, but are not limited to, parenteral administration (e.g., intradermal, intramuscular, intraperitoneal, intravenous and subcutaneous), epidural administration, intratumoral administration, mucosal

administration (e.g., intranasal and oral routes) and pulmonary administration (e.g., aerosolized compounds administered with an inhaler or nebulizer). The formulation of pharmaceutical compositions for specific routes of administration, and the materials and techniques necessary for the various methods of administration are available and known to one skilled in the art (e.g., US Patent Publication No. 20090311253 A1).

[0199] Dosage regimens may be adjusted to provide the optimum desired response (e.g., a therapeutic or prophylactic response). For example, a single bolus may be administered, several divided doses may be administered over time or the dose may be proportionally reduced or increased as indicated by the exigencies of the therapeutic situation. It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. The term "dosage unit form" refers to physically discrete units suited as unitary dosages for the mammalian subjects to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms provided herein are dictated by and directly dependent on (a) the unique characteristics of the active compound and the particular therapeutic or prophylactic effect to be achieved, and (b) the limitations inherent in the art of compounding such an active compound for the treatment of sensitivity in individuals.

An exemplary, non-limiting range for a therapeutically or prophylactically effective amount of a binding protein provided herein is 0.1-20 mg/kg, for example, 1-10 mg/kg. It is to be noted that dosage values may vary with the type and severity of the condition to be alleviated. It is to be further understood that for any particular subject, specific dosage regimens may be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that dosage ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed composition.

Combination Therapy

[0200] A binding protein provided herein also can also be administered with one or more additional therapeutic agents useful in the treatment of various diseases, the additional agent being selected by the skilled artisan for its intended purpose. For example, the additional agent can be a therapeutic agent art-recognized as being

useful to treat the disease or condition being treated by the antibody provided herein. The combination can also include more than one additional agent, e.g., two or three additional agents.

[0201] Combination therapy agents include, but are not limited to, antineoplastic agents, radiotherapy, chemotherapy such as DNA alkylating agents, cisplatin, carboplatin, anti-tubulin agents, paclitaxel, docetaxel, taxol, doxorubicin, gemcitabine, gemzar, anthracyclines, adriamycin, topoisomerase I inhibitors, topoisomerase II inhibitors, 5-fluorouracil (5-FU), leucovorin, irinotecan, receptor tyrosine kinase inhibitors (e.g., erlotinib, gefitinib), COX-2 inhibitors (e.g., celecoxib), kinase inhibitors, and siRNAs.

[0202] Combinations to treat autoimmune and inflammatory diseases may include the addition of non-steroidal anti-inflammatory drug(s), also referred to as NSAIDS, which include drugs like ibuprofen. Other combinations are corticosteroids including prednisolone; the well known side-effects of steroid use can be reduced or even eliminated by tapering the steroid dose required when treating patients in combination with the binding proteins provided herein. Non-limiting examples of therapeutic agents for rheumatoid arthritis with which a binding protein provided herein, or a binding portion thereof, can be combined include the following: cytokine suppressive anti-inflammatory drug(s) (CSAIDs); antibodies to or antagonists of other human cytokines or growth factors, for example, TNF, LT, IL-1, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-15, IL-16, IL-18, IL-21, IL-23, interferons, EMAP-II, GM-CSF, FGF, and PDGF. Binding proteins provided herein, or antigen binding portions thereof, can be combined with antibodies to cell surface molecules such as CD2, CD3, CD4, CD8, CD25, CD28, CD30, CD40, CD45, CD69, CD80 (B7.1), CD86 (B7.2), CD90, CTLA or their ligands including CD154 (gp39 or CD40L).

[0203] Combinations of therapeutic agents may interfere at different points in the autoimmune and subsequent inflammatory cascade; one or more of the following may therefore be administered in combination with a binding protein disclosed herein. Examples include a binding protein disclosed herein and a TNF antagonist like a chimeric, humanized or human TNF antibody, Adalimumab, (PCT Publication No. WO 97/29131), CA2 (RemicadeTM), CDP 571, a soluble p55 or p75 TNF receptor, or derivative thereof (p75TNFR1gG (EnbrelTM) or p55TNFR1gG (Lenercept)), a TNF α converting enzyme (TACE) inhibitor; or an IL-1 inhibitor (an Interleukin-1-converting enzyme inhibitor, IL-1RA, etc.). Other combinations include a binding protein disclosed herein and Interleukin 11. Yet another combination include key players of

the autoimmune response which may act parallel to, dependent on or in concert with IL-12 function; especially relevant are IL-18 antagonists including an IL-18 antibody, a soluble IL-18 receptor, or an IL-18 binding protein. It has been shown that IL-12 and IL-18 have overlapping but distinct functions and a combination of antagonists to both may be most effective. Yet another combination is a binding protein disclosed herein and a non-depleting anti-CD4 inhibitor. Yet other combinations include a binding protein disclosed herein and an antagonist of the co-stimulatory pathway CD80 (B7.1) or CD86 (B7.2) including an antibody, a soluble receptor, or an antagonistic ligand.

[0204] The binding proteins provided herein may also be combined with an agent, such as methotrexate, 6-MP, azathioprine sulphasalazine, mesalazine, olsalazine chloroquine/hydroxychloroquine, pencillamine, aurothiomalate (intramuscular and oral), azathioprine, cochlincine, a corticosteroid (oral, inhaled and local injection), a beta-2 adrenoreceptor agonist (salbutamol, terbutaline, salmeteral), a xanthine (theophylline, aminophylline), cromoglycate, nedocromil, ketotifen, ipratropium, oxitropium, cyclosporin, FK506, rapamycin, mycophenolate mofetil, leflunomide, an NSAID, for example, ibuprofen, a corticosteroid such as prednisolone, a phosphodiesterase inhibitor, an adenosine agonist, an antithrombotic agent, a complement inhibitor, an adrenergic agent, an agent which interferes with signalling by proinflammatory cytokines such as TNF- α or IL-1 (e.g., IRAK, NIK, IKK, p38 or a MAP kinase inhibitor), an IL-1 β converting enzyme inhibitor, a TNF α converting enzyme (TACE) inhibitor, a T-cell signalling inhibitor such as a kinase inhibitor, a metalloproteinase inhibitor, sulfasalazine, azathioprine, a 6-mercaptopurine, an angiotensin converting enzyme inhibitor, a soluble cytokine receptor or derivative thereof (e.g., a soluble p55 or p75 TNF receptor or the derivative p75TNFRIgG (EnbrelTM) or p55TNFRIgG (Lenercept), sIL-1RI, sIL-1RII, sIL-6R), an antiinflammatory cytokine (e.g., IL-4, IL-10, IL-11, IL-13 and TGF β), celecoxib, folic acid, hydroxychloroquine sulfate, rofecoxib, etanercept, infliximab, naproxen, valdecoxib, sulfasalazine, methylprednisolone, meloxicam, methylprednisolone acetate, gold sodium thiomalate, aspirin, triamcinolone acetonide, propoxyphene napsylate/apap, folate, nabumetone, diclofenac, piroxicam, etodolac, diclofenac sodium, oxaprozin, oxycodone hcl, hydrocodone bitartrate/apap, diclofenac sodium/misoprostol, fentanyl, anakinra, human recombinant, tramadol hcl, salsalate, sulindac, cyanocobalamin/fa/pyridoxine, acetaminophen, alendronate sodium, prednisolone, morphine sulfate, lidocaine hydrochloride, indomethacin, glucosamine sulf/chondroitin, amitriptyline hcl, sulfadiazine, oxycodone hcl/acetaminophen,

olopatadine hcl, misoprostol, naproxen sodium, omeprazole, cyclophosphamide, rituximab, IL-1 TRAP, MRA, CTLA4-IG, IL-18 BP, anti-IL-18, Anti-IL15, BIRB-796, SCIO-469, VX-702, AMG-548, VX-740, Roflumilast, IC-485, CDC-801, or Mesopram. Combinations include methotrexate or leflunomide and in moderate or severe rheumatoid arthritis cases, cyclosporine.

[0205] In one embodiment, the binding protein or antigen-binding portion thereof, is administered in combination with one of the following agents for the treatment of rheumatoid arthritis: a small molecule inhibitor of KDR, a small molecule inhibitor of Tie-2; methotrexate; prednisone; celecoxib; folic acid; hydroxychloroquine sulfate; rofecoxib; etanercept; infliximab; leflunomide; naproxen; valdecoxib; sulfasalazine; methylprednisolone; ibuprofen; meloxicam; methylprednisolone acetate; gold sodium thiomalate; aspirin; azathioprine; triamcinolone acetonide; propoxyphene napsylate/apap; folate; nabumetone; diclofenac; piroxicam; etodolac; diclofenac sodium; oxaprozin; oxycodone hcl; hydrocodone bitartrate/apap; diclofenac sodium/misoprostol; fentanyl; anakinra, human recombinant; tramadol hcl; salsalate; sulindac; cyanocobalamin/fa/pyridoxine; acetaminophen; alendronate sodium; prednisolone; morphine sulfate; lidocaine hydrochloride; indomethacin; glucosamine sulfate/chondroitin; cyclosporine; amitriptyline hcl; sulfadiazine; oxycodone hcl/acetaminophen; olopatadine hcl; misoprostol; naproxen sodium; omeprazole; mycophenolate mofetil; cyclophosphamide; rituximab; IL-1 TRAP; MRA; CTLA4-IG; IL-18 BP; IL-12/23; anti-IL 18; anti-IL 15; BIRB-796; SCIO-469; VX-702; AMG-548; VX-740; Roflumilast; IC-485; CDC-801; or mesopram.

[0206] Non-limiting examples of therapeutic agents for inflammatory bowel disease with which a binding protein provided herein can be combined include the following: budenoside; epidermal growth factor; a corticosteroid; cyclosporin, sulfasalazine; aminosalicylates; 6-mercaptopurine; azathioprine; metronidazole; a lipoxygenase inhibitor; mesalamine; olsalazine; balsalazide; an antioxidant; a thromboxane inhibitor; an IL-1 receptor antagonist; an anti-IL-1 β mAb; an anti-IL-6 mAb; a growth factor; an elastase inhibitor; a pyridinyl-imidazole compound; an antibody to or antagonist of other human cytokines or growth factors, for example, TNF, LT, IL-1, IL-2, IL-6, IL-7, IL-8, IL-15, IL-16, IL-17, IL-18, EMAP-II, GM-CSF, FGF, or PDGF. Antibodies provided herein, or antigen binding portions thereof, can be combined with an antibody to a cell surface molecule such as CD2, CD3, CD4, CD8, CD25, CD28, CD30, CD40, CD45, CD69, CD90 or their ligands. The antibodies provided herein, or antigen binding portions thereof, may also be combined with an

agent, such as methotrexate, cyclosporin, FK506, rapamycin, mycophenolate mofetil, leflunomide, an NSAID, for example, ibuprofen, a corticosteroid such as prednisolone, a phosphodiesterase inhibitor, an adenosine agonist, an antithrombotic agent, a complement inhibitor, an adrenergic agent, an agent which interferes with signalling by proinflammatory cytokines such as TNF α or IL-1 (e.g., an IRAK, NIK, IKK, p38 or MAP kinase inhibitor), an IL-1 β converting enzyme inhibitor, a TNF α converting enzyme inhibitor, a T-cell signalling inhibitor such as a kinase inhibitor, a metalloproteinase inhibitor, sulfasalazine, azathioprine, a 6-mercaptopurine, an angiotensin converting enzyme inhibitor, a soluble cytokine receptor or derivative thereof (e.g., a soluble p55 or p75 TNF receptor, sIL-1RI, sIL-1RII, sIL-6R) or an antiinflammatory cytokine (e.g., IL-4, IL-10, IL-11, IL-13 or TGF β) or a bcl-2 inhibitor.

[0207] Examples of therapeutic agents for Crohn's disease in which a binding protein can be combined include the following: a TNF antagonist, for example, an anti-TNF antibody, Adalimumab (PCT Publication No. WO 97/29131; HUMIRA), CA2 (REMICADE), CDP 571, a TNFR-Ig construct, (p75TNFRIgG (ENBREL) or a p55TNFRIgG (LENERCEPT)) inhibitor or a PDE4 inhibitor. Antibodies provided herein, or antigen binding portions thereof, can be combined with a corticosteroid, for example, budenoside and dexamethasone. Binding proteins provided herein or antigen binding portions thereof, may also be combined with an agent such as sulfasalazine, 5-aminosalicylic acid and olsalazine, or an agent that interferes with the synthesis or action of a proinflammatory cytokine such as IL-1, for example, an IL-1 β converting enzyme inhibitor or IL-1ra. Antibodies provided herein or antigen binding portion thereof may also be used with a T cell signaling inhibitor, for example, a tyrosine kinase inhibitor or an 6-mercaptopurine. Binding proteins provided herein, or antigen binding portions thereof, can be combined with IL-11. Binding proteins provided herein, or antigen binding portions thereof, can be combined with mesalamine, prednisone, azathioprine, mercaptopurine, infliximab, methylprednisolone sodium succinate, diphenoxylate/atrop sulfate, loperamide hydrochloride, methotrexate, omeprazole, folate, ciprofloxacin/dextrose-water, hydrocodone bitartrate/apap, tetracycline hydrochloride, fluocinonide, metronidazole, thimerosal/boric acid, cholestyramine/sucrose, ciprofloxacin hydrochloride, hyoscyamine sulfate, meperidine hydrochloride, midazolam hydrochloride, oxycodone hcl/acetaminophen, promethazine hydrochloride, sodium phosphate, sulfamethoxazole/trimethoprim, celecoxib, polycarbophil, propoxyphene napsylate, hydrocortisone, multivitamins, balsalazide disodium, codeine phosphate/apap,

colesevelam hcl, cyanocobalamin, folic acid, levofloxacin, methylprednisolone, natalizumab or interferon-gamma

[0208] Non-limiting examples of therapeutic agents for multiple sclerosis with which binding proteins provided herein can be combined include the following: a corticosteroid; prednisolone; methylprednisolone; azathioprine; cyclophosphamide; cyclosporine; methotrexate; 4-aminopyridine; tizanidine; interferon- β 1a (AVONEX; Biogen); interferon- β 1b (BETASERON; Chiron/Berlex); interferon α -n3 (Interferon Sciences/Fujimoto), interferon- α (Alfa Wassermann/J&J), interferon β 1A-IF (Serono/Inhale Therapeutics), Peginterferon α 2b (Enzon/Schering-Plough), Copolymer 1 (Cop-1; COPAXONE; Teva Pharmaceutical Industries, Inc.); hyperbaric oxygen; intravenous immunoglobulin; clabribine; an antibody to or antagonist of other human cytokines or growth factors and their receptors, for example, TNF, LT, IL-1, IL-2, IL-6, IL-7, IL-8, IL-23, IL-15, IL-16, IL-18, EMAP-II, GM-CSF, FGF, or PDGF. Binding proteins provided herein can be combined with an antibody to a cell surface molecule such as CD2, CD3, CD4, CD8, CD19, CD20, CD25, CD28, CD30, CD40, CD45, CD69, CD80, CD86, CD90 or their ligands. Binding proteins provided herein, may also be combined with an agent, such as methotrexate, cyclosporine, FK506, rapamycin, mycophenolate mofetil, leflunomide, an NSAID, for example, ibuprofen, a corticosteroid such as prednisolone, a phosphodiesterase inhibitor, an adenosine agonist, an antithrombotic agent, a complement inhibitor, an adrenergic agent, an agent which interferes with signalling by a proinflammatory cytokine such as TNF α or IL-1 (e.g., IRAK, NIK, IKK, p38 or a MAP kinase inhibitor), an IL-1 β converting enzyme inhibitor, a TACE inhibitor, a T-cell signaling inhibitor such as a kinase inhibitor, a metalloproteinase inhibitor, sulfasalazine, azathioprine, a 6-mercaptopurine, an angiotensin converting enzyme inhibitor, a soluble cytokine receptor or derivatives thereof (e.g., a soluble p55 or p75 TNF receptor, sIL-1RI, sIL-1RII, sIL-6R), an antiinflammatory cytokine (e.g., IL-4, IL-10, IL-13 or TGF β) or a bcl-2 inhibitor.

[0209] Examples of therapeutic agents for multiple sclerosis with which binding proteins provided herein can be combined include interferon- β , for example, IFN β 1a and IFN β 1b; copaxone, corticosteroids, caspase inhibitors, for example inhibitors of caspase-1, IL-1 inhibitors, TNF inhibitors, and antibodies to CD40 ligand and CD80.

[0210] Non-limiting examples of therapeutic agents for asthma with which binding proteins provided herein can be combined include the following: albuterol, salmeterol/fluticasone, montelukast sodium, fluticasone propionate, budesonide,

prednisone, salmeterol xinafoate, levalbuterol hcl, albuterol sulfate/ipratropium, prednisolone sodium phosphate, triamcinolone acetonide, beclomethasone dipropionate, ipratropium bromide, azithromycin, pirbuterol acetate, prednisolone, theophylline anhydrous, methylprednisolone sodium succinate, clarithromycin, zafirlukast, formoterol fumarate, influenza virus vaccine, methylprednisolone, amoxicillin trihydrate, flunisolide, allergy injection, cromolyn sodium, fexofenadine hydrochloride, flunisolide/menthol, amoxicillin/clavulanate, levofloxacin, inhaler assist device, guaifenesin, dexamethasone sodium phosphate, moxifloxacin hcl, doxycycline hyclate, guaifenesin/d-methorphan, p-ephedrine/cod/chlorphenir, gatifloxacin, cetirizine hydrochloride, mometasone furoate, salmeterol xinafoate, benzonatate, cephalexin, pe/hydrocodone/chlorphenir, cetirizine hcl/pseudoephed, phenylephrine/cod/promethazine, codeine/promethazine, cefprozil, dexamethasone, guaifenesin/pseudoephedrine, chlorpheniramine/hydrocodone, nedocromil sodium, terbutaline sulfate, epinephrine, methylprednisolone, metaproterenol sulfate.

[0211] Non-limiting examples of therapeutic agents for COPD with which binding proteins provided herein can be combined include the following: albuterol sulfate/ipratropium, ipratropium bromide, salmeterol/fluticasone, albuterol, salmeterol xinafoate, fluticasone propionate, prednisone, theophylline anhydrous, methylprednisolone sodium succinate, montelukast sodium, budesonide, formoterol fumarate, triamcinolone acetonide, levofloxacin, guaifenesin, azithromycin, beclomethasone dipropionate, levalbuterol hcl, flunisolide, ceftriaxone sodium, amoxicillin trihydrate, gatifloxacin, zafirlukast, amoxicillin/clavulanate, flunisolide/menthol, chlorpheniramine/hydrocodone, metaproterenol sulfate, methylprednisolone, mometasone furoate, p-ephedrine/cod/chlorphenir, pirbuterol acetate, p-ephedrine/loratadine, terbutaline sulfate, tiotropium bromide, (R,R)-formoterol, TgAAT, Cilomilast, Roflumilast.

[0212] Non-limiting examples of therapeutic agents for psoriasis with which binding proteins provided herein can be combined include the following: small molecule inhibitor of KDR, small molecule inhibitor of Tie-2, calcipotriene, clobetasol propionate, triamcinolone acetonide, halobetasol propionate, tazarotene, methotrexate, fluocinonide, betamethasone diprop augmented, fluocinolone acetonide, acitretin, tar shampoo, betamethasone valerate, mometasone furoate, ketoconazole, pramoxine/fluocinolone, hydrocortisone valerate, flurandrenolide, urea, betamethasone, clobetasol propionate/emoll, fluticasone propionate, azithromycin, hydrocortisone, moisturizing formula, folic acid, desonide, pimecrolimus, coal tar,

diflorasone diacetate, etanercept folate, lactic acid, methoxsalen, hc/bismuth subgal/znox/resor, methylprednisolone acetate, prednisone, sunscreen, halcinonide, salicylic acid, anthralin, clocortolone pivalate, coal extract, coal tar/salicylic acid, coal tar/salicylic acid/sulfur, desoximetasone, diazepam, emollient, fluocinonide/emollient, mineral oil/castor oil/na lact, mineral oil/peanut oil, petroleum/isopropyl myristate, psoralen, salicylic acid, soap/tribromsalan, thimerosal/boric acid, celecoxib, infliximab, cyclosporine, alefacept, efalizumab, tacrolimus, pimecrolimus, PUVA, UVB, sulfasalazine.

[0213] Examples of therapeutic agents for SLE (Lupus) with which binding proteins provided herein can be combined include the following: NSAIDS, for example, diclofenac, naproxen, ibuprofen, piroxicam, indomethacin; COX2 inhibitors, for example, Celecoxib, rofecoxib, valdecoxib; anti-malarials, for example, hydroxychloroquine; Steroids, for example, prednisone, prednisolone, budenoside, dexamethasone; Cytotoxics, for example, azathioprine, cyclophosphamide, mycophenolate mofetil, methotrexate; inhibitors of PDE4 or purine synthesis inhibitor, for example Cellcept. Binding proteins provided herein may also be combined with agents such as sulfasalazine, 5-aminosalicylic acid, olsalazine, Imuran and agents which interfere with synthesis, production or action of proinflammatory cytokines such as IL-1, for example, caspase inhibitors like IL-1 β converting enzyme inhibitors and IL-1ra. Binding proteins provided herein may also be used with T cell signaling inhibitors, for example, tyrosine kinase inhibitors; or molecules that target T cell activation molecules, for example, CTLA-4-IgG or anti-B7 family antibodies, anti-PD-1 family antibodies. Binding proteins provided herein, can be combined with IL-11 or anti-cytokine antibodies, for example, fonotolizumab (anti-IFN γ antibody), or anti-receptor antibodies, for example, anti-IL-6 receptor antibody and antibodies to B-cell surface molecules. Antibodies provided herein or antigen binding portion thereof may also be used with LJP 394 (abetimus), agents that deplete or inactivate B-cells, for example, Rituximab (anti-CD20 antibody), lymphostat-B (anti-BlyS antibody), TNF antagonists, for example, anti-TNF antibodies, Adalimumab (PCT Publication No. WO 97/29131; HUMIRA), CA2 (REMICADE), CDP 571, TNFR-Ig constructs, (p75TNFR-IgG (ENBREL¹) and p55TNFR-IgG (LENERCEPT)) and bcl-2 inhibitors, because bcl-2 overexpression in transgenic mice has been demonstrated to cause a lupus like phenotype (see Marquina). The pharmaceutical compositions provided herein may include a "therapeutically effective amount" or a "prophylactically effective amount" of a binding protein provided herein. A "therapeutically effective amount"

refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic result. A therapeutically effective amount of the binding protein may be determined by a person skilled in the art and may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the binding protein to elicit a desired response in the individual. A therapeutically effective amount is also one in which any toxic or detrimental effects of the antibody, or antibody binding portion, are outweighed by the therapeutically beneficial effects. A "prophylactically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired prophylactic result. Typically, since a prophylactic dose is used in subjects prior to or at an earlier stage of disease, the prophylactically effective amount will be less than the therapeutically effective amount.

Diagnostics

[0214] The disclosure herein also provides diagnostic applications including, but not limited to, diagnostic assay methods, diagnostic kits containing one or more binding proteins, and adaptation of the methods and kits for use in automated and/or semi-automated systems. The methods, kits, and adaptations provided may be employed in the detection, monitoring, and/or treatment of a disease or disorder in an individual. This is further elucidated below.

D. Method of assay

[0215] The present disclosure also provides a method for determining the presence, amount or concentration of an analyte, or fragment thereof, in a test sample using at least one binding protein as described herein. Any suitable assay as is known in the art can be used in the method. Examples include, but are not limited to, immunoassays and/or methods employing mass spectrometry.

[0216] Immunoassays provided by the present disclosure may include sandwich immunoassays, radioimmunoassay (RIA), enzyme immunoassay (EIA), enzyme-linked immunosorbent assay (ELISA), competitive-inhibition immunoassays, fluorescence polarization immunoassay (FPIA), enzyme multiplied immunoassay technique (EMIT), bioluminescence resonance energy transfer (BRET), and homogenous chemiluminescent assays, among others.

[0217] A chemiluminescent microparticle immunoassay, in particular one employing the ARCHITECT® automated analyzer (Abbott Laboratories, Abbott Park, IL), is an example of an immunoassay.

[0218] Methods employing mass spectrometry are provided by the present disclosure and include, but are not limited to MALDI (matrix-assisted laser desorption/ionization) or by SELDI (surface-enhanced laser desorption/ionization).

[0219] Methods for collecting, handling, processing, and analyzing biological test samples using immunoassays and mass spectrometry would be well-known to one skilled in the art, are provided for in the practice of the present disclosure (US 2009-0311253 A1).

E. Kit

[0220] A kit for assaying a test sample for the presence, amount or concentration of an analyte, or fragment thereof, in a test sample is also provided. The kit comprises at least one component for assaying the test sample for the analyte, or fragment thereof, and instructions for assaying the test sample for the analyte, or fragment thereof. The at least one component for assaying the test sample for the analyte, or fragment thereof, can include a composition comprising a binding protein, as disclosed herein, and/or an anti-analyte binding protein (or a fragment, a variant, or a fragment of a variant thereof), which is optionally immobilized on a solid phase.

[0221] Optionally, the kit may comprise a calibrator or control, which may comprise isolated or purified analyte. The kit can comprise at least one component for assaying the test sample for an analyte by immunoassay and/or mass spectrometry. The kit components, including the analyte, binding protein, and/or anti-analyte binding protein, or fragments thereof, may be optionally labeled using any art-known detectable label. The materials and methods for the creation provided for in the practice of the present disclosure would be known to one skilled in the art (US 2009-0311253 A1).

F. Adaptation of kit and method

[0222] The kit (or components thereof), as well as the method of determining the presence, amount or concentration of an analyte in a test sample by an assay, such as an immunoassay as described herein, can be adapted for use in a variety of automated and semi-automated systems (including those wherein the solid phase comprises a microparticle), as described, for example, in US Patent Nos. 5,089,424 and 5,006,309, and as commercially marketed, for example, by Abbott Laboratories (Abbott Park, IL) as ARCHITECT®.

[0223] Other platforms available from Abbott Laboratories include, but are not limited to, AxSYM®, IMx® (see, for example, US Patent No. 5,294,404, PRISM®, EIA (bead), and Quantum™ II, as well as other platforms. Additionally, the assays, kits and kit components can be employed in other formats, for example, on electrochemical or other hand-held or point-of-care assay systems. The present disclosure is, for example, applicable to the commercial Abbott Point of Care (i-STAT®, Abbott Laboratories) electrochemical immunoassay system that performs sandwich immunoassays. Immunosensors and their methods of manufacture and operation in single-use test devices are described, for example in, US Patent No. 5,063,081, 7,419,821, and 7,682,833; and US Publication Nos. 20040018577, 20060160164 and US 20090311253.

[0224] It will be readily apparent to those skilled in the art that other suitable modifications and adaptations of the methods described herein are obvious and may be made using suitable equivalents without departing from the scope of the embodiments disclosed herein. Having now described certain embodiments in detail, the same will be more clearly understood by reference to the following examples, which are included for purposes of illustration only and are not intended to be limiting.

EXAMPLES

Example 1: Generation and Characterization of anti-IL-1 β and anti-IL-17 Dual Variable Domain (DVD) Binding Proteins

[0225] Two and four-chain dual variable domain (DVD) binding proteins, using variable domains from parent antibodies, were generated by synthesizing polynucleotide fragments encoding DVD-Ig binding protein variable heavy and variable light chain sequences and cloning the fragments into a pHybC-D2 vector according to art known methods. The DVD-Ig binding protein constructs were cloned into and expressed in 293 cells and purified according to art known methods. DVD VH and VL chains for the DVD-Ig binding proteins are provided below. The SEQ ID NOs listed in the first column of Table 2 refer to the sequences for the full variable domains of the DVD-Ig binding proteins identified in each row of the Table. Each row in the last column of Table 2 provides three SEQ ID NOs. The first number refers to the SEQ ID NO of the outer variable domain sequence, the second number refers to the SEQ ID NO of the linker, and the third number refers to the SEQ ID NO of the inner variable domain sequence, which together are found within the full DVD variable domain sequence (i.e., the full DVD variable domain comprising VD1-X1-VD2).

Table 2: DVD-Ig Binding Proteins That Bind IL-1 β and IL-17

SEQ ID NO	DVD-Ig Variable Domain Name	Outer Variable Domain Name (VD1)	Linker	Inner Variable Domain Name (VD2)	SEQ ID NO VD1 – X1 – VD2 Formula
48	DVD2423H	AB268VH	HG-short	AB420VH	32-21-44
49	DVD2423L	AB268VL	LK-short	AB420VL	33-13-45
50	DVD2424H	AB268VH	HG-short	AB420VH	32-21-44
51	DVD2424L	AB268VL	LK-long	AB420VL	33-14-45
52	DVD2425H	AB268VH	HG-long	AB420VH	32-22-44
53	DVD2425L	AB268VL	LK-short	AB420VL	33-13-45
54	DVD2426H	AB268VH	HG-long	AB420VH	32-22-44
55	DVD2426L	AB268VL	LK-long	AB420VL	33-14-45
56	DVD2427H	AB269VH	HG-short	AB420VH	34-21-44
57	DVD2427L	AB269VL	LK-short	AB420VL	35-13-45
58	DVD2428H	AB269VH	HG-short	AB420VH	34-21-44
59	DVD2428L	AB269VL	LK-long	AB420VL	35-14-45
60	DVD2429H	AB269VH	HG-long	AB420VH	34-22-44
61	DVD2429L	AB269VL	LK-short	AB420VL	35-13-45
62	DVD2430H	AB269VH	HG-long	AB420VH	34-22-44
63	DVD2430L	AB269VL	LK-long	AB420VL	35-14-45
64	DVD2431H	AB270VH	HG-short	AB420VH	36-21-44
65	DVD2431L	AB270VL	LK-short	AB420VL	37-13-45
66	DVD2432H	AB270VH	HG-short	AB420VH	36-21-44
67	DVD2432L	AB270VL	LK-long	AB420VL	37-14-45
68	DVD2433H	AB270VH	HG-long	AB420VH	36-22-44
69	DVD2433L	AB270VL	LK-short	AB420VL	37-13-45
70	DVD2434H	AB270VH	HG-long	AB420VH	36-22-44
71	DVD2434L	AB270VL	LK-long	AB420VL	37-14-45
72	DVD2435H	AB271VH	HG-short	AB420VH	38-21-44
73	DVD2435L	AB271VL	LK-short	AB420VL	39-13-45

74	DVD2436H	AB271VH	HG-short	AB420VH	38-21-44
75	DVD2436L	AB271VL	LK-long	AB420VL	39-14-45
76	DVD2437H	AB271VH	HG-long	AB420VH	38-22-44
77	DVD2437L	AB271VL	LK-short	AB420VL	39-13-45
78	DVD2438H	AB271VH	HG-long	AB420VH	38-22-44
79	DVD2438L	AB271VL	LK-long	AB420VL	39-14-45
80	DVD2439H	AB272VH	HG-short	AB420VH	40-21-44
81	DVD2439L	AB272VL	LK-short	AB420VL	41-13-45
82	DVD2440H	AB272VH	HG-short	AB420VH	40-21-44
83	DVD2440L	AB272VL	LK-long	AB420VL	41-14-45
84	DVD2441H	AB272VH	HG-long	AB420VH	40-22-44
85	DVD2441L	AB272VL	LK-short	AB420VL	41-13-45
86	DVD2442H	AB272VH	HG-long	AB420VH	40-22-44
87	DVD2442L	AB272VL	LK-long	AB420VL	41-14-45
88	DVD3410H	AB268VH	GS-H10	AB273VH	32-29-42
89	DVD3410L	AB268VL	GS-L10	AB273VL	33-30-43
90	DVD3411H	AB269VH	GS-H10	AB273VH	34-29-42
91	DVD3411L	AB269VL	GS-L10	AB273VL	35-30-43
92	DVD3412H	AB270VH	GS-H10	AB273VH	36-29-42
93	DVD3412L	AB270VL	GS-L10	AB273VL	37-30-43
94	DVD3413H	AB271VH	GS-H10	AB273VH	38-29-42
95	DVD3413L	AB271VL	GS-L10	AB273VL	39-30-43
96	DVD3414H	AB272VH	GS-H10	AB273VH	40-29-42
97	DVD3414L	AB272VL	GS-L10	AB273VL	41-30-43
98	DVD3415H	AB268VH	GS-H10	AB420VH	32-29-44
99	DVD3415L	AB268VL	GS-L10	AB420VL	33-30-45
100	DVD3416H	AB270VH	GS-H10	AB461VH	36-29-46
101	DVD3416L	AB270VL	GS-L10	AB461VL	37-30-47
102	DVD3417H	AB268VH	GS-H10	AB461VH	32-29-46

103	DVD3417L	AB268VL	GS-L10	AB461VL	33-30-47
104	DVD3418H	AB269VH	GS-H10	AB420VH	34-29-44
105	DVD3418L	AB269VL	GS-L10	AB420VL	35-30-45
106	DVD3419H	AB270VH	HG-short	AB461VH	36-21-46
107	DVD3419L	AB270VL	LK-short	AB461VL	37-13-47
108	DVD3420H	AB268VH	HG-short	AB461VH	32-21-46
109	DVD3420L	AB268VL	LK-long	AB461VL	33-14-47
110	DVD3421H	AB271VH	HG-short	AB461VH	38-21-46
111	DVD3421L	AB271VL	LK-short	AB461VL	39-13-47
112	DVD3422H	AB269VH	HG-short	AB461VH	34-21-46
113	DVD3422L	AB269VL	LK-long	AB461VL	35-14-47
114	DVD3423H	AB270VH	HG-short	AB461VH	36-21-46
115	DVD3423L	AB270VL	LK-long	AB461VL	37-14-47
116	DVD3424H	AB272VH	HG-short	AB461VH	40-21-46
117	DVD3424L	AB272VL	LK-long	AB461VL	41-14-47
118	DVD3425H	AB272VH	HG-long	AB461VH	40-22-46
119	DVD3425L	AB272VL	LK-short	AB461VL	41-13-47

All DVD-Ig binding proteins listed above may further comprise a human light chain Kappa constant region. DVD2423-DVD2442 may also comprise a human heavy chain wild-type IgG1 constant region, while DVD3410-DVD3425 may comprise a heavy chain constant region from a human IgG1 mutant (IgG1, z, non-a mut (234,235)). Sequences for these heavy and light chain constant regions are shown in Table 2a below. For instance, DVD3418 may further comprise a heavy chain constant region from a human IgG1 mutant (IgG1, z, mut (234,235)) and a light chain constant region from a human light chain Kappa constant region (see Table 2b, showing the amino acid sequences of the first and second chains of DVD3418, with the CDR sequences underlined and the X1 linkers in bold, and showing potential constant domain sequences in italics, with the mutated constant domain amino acids on the heavy chain in bold and underlined).

Table 2a: Human IgG Heavy and Light Chain Constant Domains

Protein	SEQ ID NO	Sequence
		12345678901234567890123456789012345678901234567890123
Wild type hlgG1 constant region		ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVFSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLEGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWE SNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSQSVMHREALNHYTQKSLSLSPGK
Mutant hlgG1 constant region (IgG1, z, non-a mut (234,235))		ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVFSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWE SNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSQSVMHREALNHYTQKSLSLSPGK
Ig kappa constant region		TVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
Ig Lambda constant region		OPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGVE TTPPSKQSNKNKYAASSYLSTLTPQWKSHRSYSCQVTHEGSTVEKTVAPTECS

Table 2b: Amino Acid Sequence for DVD3418 with Constant Region

DVD3418	SEQ ID NO	Sequence
		12345678901234567890123456789012345678901234567890123
first chain		EVQLVESGGGVVQPGRSRLRLSCSASGFI FSRDYDMSWVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTISRDN SKNTLFLQMDSLKAEDTAVYYCARGGVYKGYFDVWGQGTPTVTVSSGGGGSGGGGSEVQLVQSGAEVKKPGSSVKVSKKASGGSGFGYGGIGWVRQAPGQGLEWMGGITPFFFGFADYAOKFQGRVTITADESTTTAYMELSGLTSDDTAVYYCARDPNEFWGGYYSTHDFDSWGQGTPTVTVSSASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVFSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPEAAGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWE SNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSQSVMHREALNHYTQKSLSLSPGK
second chain		DIQMTQSPSSLSASVGDRVTITCRASGNIHNYLTWYQQTPGKAPKLLIYNKTLADGVPSRFSGSGSGTDYTFITISSLQPEDIAITYYCQHFWSIPYTFGQGTCLQITRGSGGGGSGGEIVLTQSPDFQSVPKPKVTITCRASQDIGSELHWYQQKPDQPPKLLIKYASHSTSGVPSRFSGSGSGTDFTLTINGLEAEADAGTYCHQDTSLEPTFGPGTKVDIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSSTYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

Example 2: Assays Used To Determine the Functional Activity Of Parent Antibodies And DVD-Ig Proteins

Example 2.1: IL- β Bioassay and Neutralization Assay

[0226] MRC5 cells were plated at $1.5\text{--}2 \times 10^4$ cells per well in a 100 μl volume and incubated overnight at 37°C , 5% CO_2 . A 20 $\mu\text{g/ml}$ working stock of antibody (4x concentrated) was prepared in complete MEM medium. An eight point serial dilution was performed (5 $\mu\text{g/ml}$ –0.0003 $\mu\text{g/ml}$) in complete MEM in Marsh dilution plates. Seventy-five μl /well of each antibody dilution was added in quadruplicate to a 96 well v-bottom (Costar# 3894) plate and 75 μl of a 200 pg/ml solution of IL-1 β . Control wells received 75 μl 200 pg/ml of IL-1 β (4x concentrated) plus 75 μl MEM media and media control wells received 150 μl of media. Following a 1 hour incubation, 100 μl of the Ab/Ag mixture was added to the MRC5 cells. All well volumes were equal to 200 μl . All plate reagents were then 1x concentrated. After a 16–20 hour incubation, the well contents (150 μl) were transferred into a 96-well round bottom plate (Costar# 3799) and placed in a -20°C freezer. The supernatants were tested for hIL-8 levels by using a human IL-8 ELISA kit (R&D Systems, Minneapolis, MN) or hIL-8 chemiluminescence kit (MDS). Neutralization potency was determined by calculating percent inhibition relative to the IL-1 β alone control value. Results are shown in Table 3.

Table 3: IL-1 β Neutralization Assay With IL-1 β Parent Antibody and DVD-Ig Protein

Parent Antibody or DVD-Ig ID	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	N-Terminal VD IL-1 β Neutralization Assay (IC50 nM)
AB268	IL-1b (seq1)		0.012
AB269	IL-1b (seq 2)		0.0009
AB270	IL-1b (seq 3)		0.239
AB271	IL-1b (seq 4)		0.301
AB272	IL-1b (seq 5)		0.424
DVD2423	IL-1b (seq 1)	IL-17 (seq 2)	0.016
DVD2424	IL-1b (seq 1)	IL-17 (seq 2)	0.021
DVD2425	IL-1b (seq 1)	IL-17 (seq 2)	0.016
DVD2426	IL-1b (seq 1)	IL-17 (seq 2)	0.026
DVD2427	IL-1b (seq 2)	IL-17 (seq 2)	0.0003
DVD2428	IL-1b (seq 2)	IL-17 (seq 2)	0.0007
DVD2429	IL-1b (seq 2)	IL-17 (seq 2)	0.0009
DVD2430	IL-1b (seq 2)	IL-17 (seq 2)	0.0018

DVD2431	IL-1b (seq 3)	IL-17 (seq 2)	0.168
DVD2432	IL-1b (seq 3)	IL-17 (seq 2)	0.194
DVD2433	IL-1b (seq 3)	IL-17 (seq 2)	0.295
DVD2434	IL-1b (seq 3)	IL-17 (seq 2)	0.29800
DVD2435	IL-1b (seq 4)	IL-17 (seq 2)	0.273
DVD2436	IL-1b (seq 4)	IL-17 (seq 2)	0.191
DVD2437	IL-1b (seq 4)	IL-17 (seq 2)	0.22
DVD2438	IL-1b (seq 4)	IL-17 (seq 2)	0.182
DVD2439	IL-1b (seq 5)	IL-17 (seq 2)	0.115
DVD2440	IL-1b (seq 5)	IL-17 (seq 2)	0.222
DVD2441	IL-1b (seq 5)	IL-17 (seq 2)	0.16
DVD2442	IL-1b (seq 5)	IL-17 (seq 2)	0.21500
DVD3415	IL-1b (seq 1)	IL-17 (seq 2)	0.027
DVD3416	IL-1b (seq 3)	IL-17 (seq 3)	2.563
DVD3417	IL-1b (seq 1)	IL-17 (seq 3)	0.041
DVD3418	IL-1b (seq 2)	IL-17 (seq 2)	0.018
DVD3419	IL-1b (seq 3)	IL-17 (seq 3)	20.4
DVD3420	IL-1b (seq 1)	IL-17 (seq 3)	0.01
DVD3422	IL-1b (seq 2)	IL-17 (seq 3)	<0.04
DVD3423	IL-1b (seq 3)	IL-17 (seq 3)	1.568
DVD3425	IL-1b (seq 5)	IL-17 (seq 3)	2.067

All DVD-Ig proteins containing VDs from AB268, AB269, AB270, AB271, or AB272 in either the N-terminal or C-terminal position demonstrated neutralization in the MRC5 IL-1 β neutralization assay.

Example 2.2: IL-17 Bioassay and Neutralization Assay

[0227] The human HS27 cell line (ATCC #CRL-1634) secretes IL-6 in response to IL-17. The IL-17-induced IL-6 secretion is inhibited by neutralizing anti-IL-17 antibodies (See, e.g., J. Immunol. 155:5483-5486 (1995) or Cytokine 9:794-800 (1997)).

[0228] HS27 cells were maintained in assay medium (DMEM high glucose medium (Gibco #11965) with 10% fetal bovine serum (Gibco#26140), 4 mM L-glutamine, 1 mM sodium pyruvate, penicillin G (100 U/500 ml) and streptomycin (100 μ g/500 ml)). Cells were grown in T150 flasks until they were about 80-90% confluent the day of the assay. Human IL-17 (R&D Systems, #317-IL/CF) was reconstituted in sterile PBS without Ca²⁺ and Mg²⁺, stored frozen, freshly thawed for use and diluted to 40 ng/ml (4X) in assay medium. Serial dilutions of antibodies were made in a separate plate (4X concentrations), mixed with an equal volume of 40ng/ml (4X) of human IL-17 and incubated at 37°C for 1 hour. HS27 cells (typically about 20,000 cells in 50 μ l assay medium) were added to each well of a 96-well flat-bottom tissue culture plate (Costar #3599), followed by the addition of 50 μ l of the pre-incubated antibody or

DVD-Ig protein plus IL-17 mix. The final concentration of IL-17 was 10ng/ml. Cells were incubated for about 24 hours at 37°C. The media supernatants were then collected. The level of IL-17 neutralization was measured by determination of IL-6 amounts in supernatant using a commercial Meso Scale Discovery kit according to manufacturer's instructions. IC50 values were obtained using logarithm of antibody or DVD-Ig protein vs. IL-6 amount variable slope fit. See Table 4.

Table 4: IL-17 Neutralization Assay With IL-17 Parent Antibody and DVD-Ig Protein

Parent Antibody or DVD-Ig ID	N-Terminal Variable Domain (VD)	C-Terminal Variable Domain (VD)	C-Terminal VD IL17 Neutralization Assay (IC50 nM)
AB273	IL-17 (seq 1)		0.031
AB274	IL-17 (seq 4)		0.02
AB420	IL-17 (seq 2)		0.018
AB461	IL-17 (seq 3)		
DVD2423	IL-1b (seq 1)	IL-17 (seq 2)	1.092
DVD2424	IL-1b (seq 1)	IL-17 (seq 2)	0.077
DVD2425	IL-1b (seq 1)	IL-17 (seq 2)	0.221
DVD2426	IL-1b (seq 1)	IL-17 (seq 2)	0.071
DVD2427	IL-1b (seq 2)	IL-17 (seq 2)	0.771
DVD2428	IL-1b (seq 2)	IL-17 (seq 2)	0.065
DVD2429	IL-1b (seq 2)	IL-17 (seq 2)	0.305
DVD2430	IL-1b (seq 2)	IL-17 (seq 2)	0.056
DVD2431	IL-1b (seq 3)	IL-17 (seq 2)	0.805
DVD2432	IL-1b (seq 3)	IL-17 (seq 2)	0.079
DVD2433	IL-1b (seq 3)	IL-17 (seq 2)	0.125
DVD2434	IL-1b (seq 3)	IL-17 (seq 2)	0.055
DVD2435	IL-1b (seq 4)	IL-17 (seq 2)	0.863
DVD2436	IL-1b (seq 4)	IL-17 (seq 2)	0.042
DVD2437	IL-1b (seq 4)	IL-17 (seq 2)	0.12
DVD2438	IL-1b (seq 4)	IL-17 (seq 2)	0.032
DVD2439	IL-1b (seq 5)	IL-17 (seq 2)	0.549
DVD2440	IL-1b (seq 5)	IL-17 (seq 2)	0.055
DVD2441	IL-1b (seq 5)	IL-17 (seq 2)	0.087
DVD2442	IL-1b (seq 5)	IL-17 (seq 2)	0.043
DVD3415	IL-1b (seq 1)	IL-17 (seq 2)	0.091
DVD3416	IL-1b (seq 3)	IL-17 (seq 3)	0.16
DVD3417	IL-1b (seq 1)	IL-17 (seq 3)	0.37
DVD3418	IL-1b (seq 2)	IL-17 (seq 2)	0.068
DVD3419	IL-1b (seq 3)	IL-17 (seq 3)	1.7
DVD3420	IL-1b (seq 1)	IL-17 (seq 3)	0.36
DVD3422	IL-1b (seq 2)	IL-17 (seq 3)	0.063
DVD3423	IL-1b (seq 3)	IL-17 (seq 3)	0.05
DVD3425	IL-1b (seq 5)	IL-17 (seq 3)	0.098

All DVD-Ig proteins containing VDs from AB273, AB420 or AB461 in either the N-terminal or C-terminal position showed neutralization in the HS27 IL-17 neutralization assay.

Example 2.3: Affinity Determination Using BIACORE Technology

Table 5: Reagents Used in Biacore Analyses

Antigen	Vendor Designation	Vendor	Catalog #
IL-17	Recombinant Human IL-17	R&D systems	317-IL
IL-1b	Recombinant Human IL-1b	R&D systems	201-LB

BIACORE Methods:

[0229] The BIACORE assay (GE, Healthcare Piscataway, NJ) determined the affinity of antibodies or DVD-Ig proteins with kinetic measurements of on-rate and off-rate constants. Binding of antibodies or DVD-Ig proteins to a target antigen (for example, a purified recombinant target antigen) was determined by surface plasmon resonance-based measurements with a Biacore T200 using running HBS-EP + buffer from GE Healthcare at 25°C. All chemicals were obtained from GE Healthcare unless otherwise described. For example, approximately 5000 RU of goat anti-mouse IgG, (Fcγ), fragment specific polyclonal antibody (Pierce Biotechnology Inc, Rockford, IL) diluted in 10 mM sodium acetate (pH 4.5) was directly immobilized across a CM5 research grade biosensor chip using a standard amine coupling kit according to manufacturer's instructions. Unreacted moieties on the biosensor surface were blocked with ethanolamine. Modified carboxymethyl dextran surface in flowcell 1 was used as a reference surface. Rate constants were derived by making kinetic binding measurements at different antigen concentrations ranging from 0.8-100 nM. Binding was recorded as a function of time and kinetic rate constants were calculated. In this assay, association rate was evaluated for 5 minutes and dissociation was monitored for 10 minutes. For kinetic screening analysis, rate equations derived from the 1:1 binding model were fitted simultaneously to association and dissociation phases of all injections (using global fit analysis with Rmax fit locally to account for capture variations) with the use of Biaevaluation software. Purified antibodies or DVD-Ig proteins were diluted in HEPES-buffered saline for capture across goat anti-mouse IgG specific reaction surfaces. Antibodies or DVD-Ig proteins to be captured as a ligand were injected over reaction matrices at a flow rate of 5 µl/minute. The association and dissociation rate constants, k_{on} ($M^{-1}s^{-1}$)

and k_{off} (s^{-1}) were determined under a continuous flow rate of 50 $\mu\text{l}/\text{minute}$. Rate constants were derived by making kinetic binding measurements at different antigen concentrations ranging from 0.8-100 nM. Binding was recorded as a function of time and kinetic rate constants were calculated. In this assay, association rate was evaluated for 5 minutes and dissociation was monitored for 10 minutes. See Table 6.

Table 6: BIACORE Analysis of Parental Antibodies and DVD-Ig Proteins

Parent Antibody or DVD-Ig ID	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	k_{on} ($\text{M}^{-1}\text{s}^{-1}$)	k_{off} (s^{-1})	k_{D} (M)
AB268	IL-1b (seq 1)		8.90E+05	2.10E-04	2.40E-10
AB269	IL-1b (seq 2)		5.40E+05	1.10E-04	2.00E-10
AB270	IL-1b (seq 3)		6.60E+06	5.30E-04	8.00E-11
AB271	IL-1b (seq 4)		4.60E+06	5.10E-04	1.10E-10
AB272	IL-1b (seq 5)		4.00E+06	5.60E-04	1.40E-10
AB273	IL-17 (seq 1)		2.70E+06	1.30E-05	4.60E-12
AB274	IL 17 (seq 4)		1.1E+06	8.2E-06	7.4E-12
AB420	IL-17 (seq 2)		8.34E+06	1.74E-06	2.09E-13
AB461	IL-17 (seq 3)		6.2E+06	5.3E-06	8.6E-13
DVD3415	IL-1b (seq 1)		7.4E+05	3.8E-05	5.1E-11
DVD3415		IL-17 (seq 2)	2.1E+05	<1e-06*	<4.8E-12
DVD3418	IL-1b (seq 2)		5.4E+05	1.8E-05	3.4E-11
DVD3418		IL-17 (seq 2)	2.1E+05	<1e-06*	<4.8E-12
DVD3416	IL-1b (seq 3)		9.2E+06	8.8E-04	9.6E-11
DVD3416		IL-17 (seq 3)	2.6E+05	5.7E-05	2.2E-10
DVD3417	IL-1b (seq 1)		2.2E+06	2.4E-05	1.1E-11
DVD3417		IL-17 (seq 3)	2.6E+05	8.3E-05	3.2E-10
DVD3419	IL-1b (seq 3)		9.5E+06	8.9E-04	9.3E-11
DVD3419		IL 17 (seq 3)	1.3E+05	5.7E-05	2.3E-10
DVD3422	IL-1b (seq 2)		1.4E+06	2.0E-06	1.4E-12
DVD3422		IL-17 (seq 3)	2.5E+05	5.7E-05	2.3E-10
DVD3423	IL-1b (seq 3)		9.9E+06	8.5E-04	8.6E-11
DVD3423		IL-17 (seq 3)	3.3E+05	6.8E-05	2.0E-10
DVD3425	IL-1b (seq 5)		9.5E+06	1.1E-03	1.2E-10
DVD3425		IL-17 (seq 3)	1.7E+05	3.2E-05	1.9E-10

All DVD-Ig proteins characterized by Biacore technology exhibited binding. All variable domains bound with similar high affinity as the parent antibodies.

Example 3: Characterization Of Antibodies and DVD-Ig Proteins

[0230] The ability of purified DVD-Ig protein to inhibit a functional activity was determined, e.g., using the cytokine bioassay as described in Examples 2.1 and 2.2.

The binding affinities of the DVD-Ig protein to recombinant human antigen were determined using surface plasmon resonance (Biacore®) measurement as described in Example 2.3. The IC₅₀ values from the bioassays and the affinity of the antibodies and DVD-Ig proteins were ranked. The DVD-Ig protein that most fully maintain the activity of the parent mAbs were selected as candidates for future development. The top two to three DVD-Ig proteins exhibiting the most favorable properties were further characterized.

Example 3.1: Pharmacokinetic Analysis Of Humanized Antibodies or DVD-Ig Protein

[0231] Pharmacokinetic studies are carried out in Sprague-Dawley rats and cynomolgus monkeys. Male and female rats and cynomolgus monkeys are dosed intravenously or subcutaneously with a single dose of 4mg/kg mAb or DVD-Ig protein and samples are analyzed using antigen capture ELISA, and pharmacokinetic parameters are determined by noncompartmental analysis. Briefly, ELISA plates are coated with goat anti-biotin antibody (5 mg/ml, 4°C, overnight), blocked with Superblock (Pierce), and incubated with biotinylated human antigen at 50 ng/ml in 10% Superblock TTBS at room temperature for 2 hours. Serum samples are serially diluted (0.5% serum, 10% Superblock in TTBS) and incubated on the plate for 30 minutes at room temperature. Detection is carried out with HRP-labeled goat anti human antibody and concentrations are determined with the help of standard curves using the four parameter logistic fit. Values for the pharmacokinetic parameters are determined by non-compartmental model using WinNonlin software (Pharsight Corporation, Mountain View, CA). Humanized mAbs with good pharmacokinetics profile (T_{1/2} is 8-13 days or better, with low clearance and excellent bioavailability 50-100%) are selected.

Example 3.2: Physicochemical And In Vitro Stability Analysis Of Humanized Monoclonal Antibodies and DVD-Ig Proteins

Size Exclusion Chromatography

[0232] Antibodies or DVD-Ig proteins were diluted to 2.5 mg/mL with water and 20 mL was analyzed on a Shimadzu HPLC system using a TSK gel G3000 SWXL column (Tosoh Bioscience, cat# k5539-05k). Samples were eluted from the column with 211 mM sodium sulfate, 92 mM sodium phosphate, pH 7.0, at a flow rate of 0.3 mL/minutes. The HPLC system operating conditions were as follows:

[0233] Mobile phase: 211 mM Na₂SO₄, 92 mM Na₂HPO₄*7H₂O, pH 7.0

[0234] Gradient: Isocratic

[0235] Flow rate: 0.3 mL/minute

[0236] Detector wavelength: 280 nm

[0237] Autosampler cooler temp: 4°C

[0238] Column oven temperature: Ambient

[0239] Run time: 50 minutes

[0240] Table 7 contains purity data of parent antibodies and DVD-Ig proteins expressed as percent monomer (unaggregated protein of the expected molecular weight) as determined by the above protocol.

Table 7: Purity of Parent Antibodies and DVD-Ig Proteins as Determined by Size Exclusion Chromatography

Parent Antibody or DVD-Ig ID	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	% Monomer (purity)
AB268	IL-1b (seq 1)		99
AB269	IL-1b (seq 2)		99
AB270	IL-1b (seq 3)		90.6
AB271	IL-1b (seq 4)		95.5
AB272	IL-1b (seq 5)		93.1
AB273	IL-17 (seq 1)		100
AB420	IL-17 (seq 2)		70.1
AB461	IL-17 (seq 3)		92.9
DVD2423	IL-1b (seq 1)	IL-17 (seq 2)	96.1
DVD2424	IL-1b (seq 1)	IL-17 (seq 2)	97.2
DVD2425	IL-1b (seq 1)	IL-17 (seq 2)	97.1
DVD2426	IL-1b (seq 1)	IL-17 (seq 2)	96.4
DVD2427	IL-1b (seq 2)	IL-17 (seq 2)	99.1
DVD2428	IL-1b (seq 2)	IL-17 (seq 2)	99
DVD2429	IL-1b (seq 2)	IL-17 (seq 2)	99.2
DVD2430	IL-1b (seq 2)	IL-17 (seq 2)	98.1
DVD2431	IL-1b (seq 3)	IL-17 (seq 2)	88.8
DVD2432	IL-1b (seq 3)	IL-17 (seq 2)	89.9
DVD2433	IL-1b (seq 3)	IL-17 (seq 2)	93.4
DVD2434	IL-1b (seq 3)	IL-17 (seq 2)	95.4
DVD2435	IL-1b (seq 4)	IL-17 (seq 2)	93.7
DVD2436	IL-1b (seq 4)	IL-17 (seq 2)	94.3
DVD2437	IL-1b (seq 4)	IL-17 (seq 2)	96.9
DVD2438	IL-1b (seq 4)	IL-17 (seq 2)	91.2
DVD2439	IL-1b (seq 5)	IL-17 (seq 2)	92.9
DVD2440	IL-1B (seq 5)	IL-17 (seq 2)	93.8
DVD2441	IL-1b (seq 5)	IL-17 (seq 2)	96.1

DVD2442	IL-1b (seq 5)	IL-17 (seq 2)	94.2
DVD3410	IL-1b (seq 1)	IL-17 (seq 1)	98.5
DVD3411	IL-1b (seq 2)	IL-17 (seq 1)	100
DVD3412	IL-1b (seq 3)	IL-17 (seq 1)	92.7
DVD3413	IL-1b (seq 4)	IL-17 (seq 1)	96.1
DVD3414	IL-1b (seq 5)	IL-17 (seq 1)	97.6
DVD3415	IL-1b (seq 1)	IL-17 (seq 2)	96.6
DVD3416	IL-1b (seq 3)	IL-17 (seq 3)	89.3
DVD3417	IL-1b (seq 1)	IL-17 (seq 3)	93.2
DVD3418	IL-1b (seq 2)	IL-17 (seq 2)	99.2
DVD3419	IL-1b (seq 3)	IL-17 (seq 3)	97.2
DVD3420	IL-1b (seq 1)	IL-17 (seq 3)	98
DVD3421	IL-1b (seq 4)	IL-17 (seq 3)	93.7
DVD3422	IL-1b (seq 2)	IL-17 (seq 3)	98.3
DVD3423	IL-1b (seq 3)	IL-17 (seq 3)	91.5
DVD3424	IL-1b (seq 5)	IL-17 (seq 3)	92.7
DVD3425	IL-1b (seq 5)	IL-17 (seq 3)	94

DVD-Ig proteins showed an excellent SEC profile with most DVD-Ig proteins showing >90% monomer. This DVD-Ig protein profile was similar to that observed for parent antibodies.

SDS-PAGE

[0241] Antibodies and DVD-Ig proteins are analyzed by sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE) under both reducing and non-reducing conditions. Adalimumab lot AFP04C is used as a control. For reducing conditions, the samples are mixed 1:1 with 2X tris glycine SDS-PAGE sample buffer (Invitrogen, cat# LC2676, lot# 1323208) with 100 mM DTT, and heated at 60°C for 30 minutes. For non-reducing conditions, the samples are mixed 1:1 with sample buffer and heated at 100°C for 5 minutes. The reduced samples (10 mg per lane) are loaded on a 12% pre-cast tris-glycine gel (Invitrogen, cat# EC6005box, lot# 6111021), and the non-reduced samples (10 mg per lane) are loaded on an 8%-16% pre-cast tris-glycine gel (Invitrogen, cat# EC6045box, lot# 6111021). SeeBlue Plus 2 (Invitrogen, cat#LC5925, lot# 1351542) is used as a molecular weight marker. The gels are run in a XCell SureLock mini cell gel box (Invitrogen, cat# EI0001) and the proteins are separated by first applying a voltage of 75 to stack the samples in the gel, followed by a constant voltage of 125 until the dye front reached the bottom of the gel. The running buffer used is 1X tris glycine SDS buffer, prepared from a 10X tris glycine SDS buffer (ABC, MPS-79-080106)). The gels are stained overnight with colloidal blue stain (Invitrogen cat# 46-7015, 46-7016) and destained with Milli-Q water until the

background is clear. The stained gels are then scanned using an Epson Expression scanner (model 1680, S/N DASX003641).

Sedimentation Velocity Analysis

[0242] Antibodies or DVD-Ig proteins are loaded into the sample chamber of each of three standard two-sector carbon epon centerpieces. These centerpieces have a 1.2 cm optical path length and are built with sapphire windows. PBS is used for a reference buffer and each chamber contained 140 μ L. All samples are examined simultaneously using a 4-hole (AN-60Ti) rotor in a Beckman ProteomeLab XL-I analytical ultracentrifuge (serial # PL106C01).

[0243] Run conditions are programmed and centrifuge control is performed using ProteomeLab (v5.6). The samples and rotor are allowed to thermally equilibrate for one hour prior to analysis (20.0 ± 0.1 °C). Confirmation of proper cell loading is performed at 3000 rpm and a single scan is recorded for each cell. The sedimentation velocity conditions are the following:

[0244] Sample Cell Volume: 420 mL

[0245] Reference Cell Volume: 420 mL

[0246] Temperature: 20°C

[0247] Rotor Speed: 35,000 rpm

[0248] Time: 8:00 hours

[0249] UV Wavelength: 280 nm

[0250] Radial Step Size: 0.003 cm

[0251] Data Collection: One data point per step without signal averaging.

[0252] Total Number of Scans: 100

LC-MS molecular weight measurement of intact antibodies

[0253] Molecular weight of intact antibodies and DVD-Ig proteins are analyzed by LC-MS. Each antibody or DVD-Ig protein is diluted to approximately 1 mg/mL with water. An 1100 HPLC (Agilent) system with a protein microtrap (Michrom Bioresources, Inc, cat# 004/25109/03) is used to desalt and introduce 5 mg of the sample into an API Qstar pulsar i mass spectrometer (Applied Biosystems). A short gradient is used to elute the samples. The gradient is run with mobile phase A (0.08% FA, 0.02% TFA in HPLC water) and mobile phase B (0.08% FA and 0.02% TFA in acetonitrile) at a flow rate of 50 mL/minute. The mass spectrometer is

operated at 4.5 kvolts spray voltage with a scan range from 2000 to 3500 mass to charge ratio.

LC-MS Molecular Weight Measurement of Antibody and DVD-Ig Protein Light and Heavy Chains

[0254] Molecular weight measurement of antibody and DVD-Ig protein light chain (LC), heavy chain (HC) and deglycosylated HC are analyzed by LC-MS. Antibodies and DVD-Ig proteins are diluted to 1 mg/mL with water and the sample is reduced to LC and HC with a final concentration of 10 mM DTT for 30 minutes at 37°C. To deglycosylate the antibodies and DVD-Ig proteins, 100 mg of the antibody or DVD-Ig protein is incubated with 2 mL of PNGase F, 5 mL of 10% N-octylglucoside in a total volume of 100 mL overnight at 37 °C. After deglycosylation the sample is reduced with a final concentration of 10 mM DTT for 30 minutes at 37°C. An Agilent 1100 HPLC system with a C4 column (Vydac, cat# 214TP5115, S/N 060206537204069) is used to desalt and introduce the sample (5 mg) into an API Qstar pulsar i mass spectrometer (Applied Biosystems). A short gradient is used to elute the sample. The gradient is run with mobile phase A (0.08% FA, 0.02% TFA in HPLC water) and mobile phase B (0.08% FA and 0.02% TFA in acetonitrile) at a flow rate of 50 mL/minute. The mass spectrometer is operated at 4.5 kvolts spray voltage with a scan range from 800 to 3500 mass to charge ratio.

Peptide Mapping

[0255] The antibody or DVD-Ig protein is denatured for 15 minutes at room temperature with a final concentration of 6 M guanidine hydrochloride in 75 mM ammonium bicarbonate. The denatured samples are reduced with a final concentration of 10 mM DTT at 37°C for 60 minutes, followed by alkylation with 50 mM iodoacetic acid (IAA) in the dark at 37°C for 30 minutes. Following alkylation, the sample is dialyzed overnight against four liters of 10 mM ammonium bicarbonate at 4°C. The dialyzed sample is diluted to 1 mg/mL with 10 mM ammonium bicarbonate, pH 7.8 and 100 mg of antibody or DVD-Ig protein is either digested with trypsin (Promega, cat# V5111) or Lys-C (Roche, cat# 11 047 825 001) at a 1:20 (w/w) trypsin/Lys-C:antibody or DVD-Ig protein ratio at 37°C for 4 hours. Digests are quenched with 1 mL of 1 N HCl. For peptide mapping with mass spectrometer detection, 40 mL of the digests are separated by reverse phase high performance liquid chromatography (RPHPLC) on a C18 column (Vydac, cat# 218TP51, S/N NE9606 10.3.5) with an Agilent 1100 HPLC system. The peptide separation is run with a gradient using mobile phase A (0.02% TFA and 0.08% FA in HPLC grade

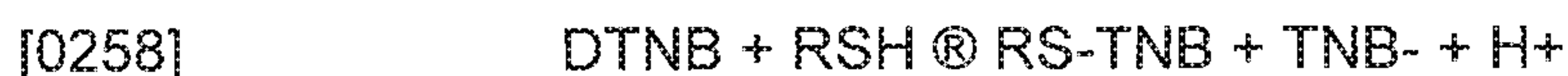
water) and mobile phase B (0.02% TFA and 0.08% FA in acetonitrile) at a flow rate of 50 mL/minutes. The API QSTAR Pulsar i mass spectrometer is operated in positive mode at 4.5 kvolts spray voltage and a scan range from 800 to 2500 mass to charge ratio.

Disulfide Bond Mapping

[0256] To denature the antibody, 100 mL of the antibody or DVD-Ig protein is mixed with 300 mL of 8 M guanidine HCl in 100 mM ammonium bicarbonate. The pH is checked to ensure that it is between 7 and 8 and the samples are denatured for 15 minutes at room temperature in a final concentration of 6 M guanidine HCl. A portion of the denatured sample (100 mL) is diluted to 600 mL with Milli-Q water to give a final guanidine-HCl concentration of 1 M. The sample (220 mg) is digested with either trypsin (Promega, cat # V5111, lot# 22265901) or Lys-C (Roche, cat# 11047825001, lot# 12808000) at a 1:50 trypsin or 1:50 Lys-C: antibody or DVD-Ig protein (w/w) ratios (4.4 mg enzyme: 220 mg sample) at 37°C for approximately 16 hours. An additional 5 mg of trypsin or Lys-C is added to the samples and digestion is allowed to proceed for an additional 2 hours at 37°C. Digestions are stopped by adding 1 mL of TFA to each sample. Digested samples are separated by RPHPLC using a C18 column (Vydac, cat# 218TP51 S/N NE020630-4-1A) on an Agilent HPLC system. The separation is run with the same gradient used for peptide mapping using mobile phase A (0.02% TFA and 0.08% FA in HPLC grade water) and mobile phase B (0.02% TFA and 0.08% FA in acetonitrile) at a flow rate of 50 mL/minute. The HPLC operating conditions are the same as those used for peptide mapping. The API QSTAR Pulsar i mass spectrometer is operated in positive mode at 4.5 kvolts spray voltage and a scan range from 800 to 2500 mass-to-charge ratio. Disulfide bonds are assigned by matching the observed MWs of peptides with the predicted MWs of tryptic or Lys-C peptides linked by disulfide bonds.

Free Sulfhydryl Determination

[0257] The method used to quantify free cysteines in an antibody or DVD-Ig protein is based on the reaction of Ellman's reagent, 5,5'-dithio-bis (2-nitrobenzoic acid) (DTNB), with sulfhydryl groups (SH) which gives rise to a characteristic chromophoric product, 5-thio-(2-nitrobenzoic acid) (TNB). The reaction is illustrated in the formula:



[0259] The absorbance of the TNB- is measured at 412 nm using a Cary 50 spectrophotometer. An absorbance curve is plotted using dilutions of 2 mercaptoethanol (b-ME) as the free SH standard and the concentrations of the free sulfhydryl groups in the protein are determined from absorbance at 412 nm of the sample.

[0260] The b-ME standard stock is prepared by a serial dilution of 14.2 M b-ME with HPLC grade water to a final concentration of 0.142 mM. Then standards in triplicate for each concentration are prepared. Antibody or DVD-Ig protein is concentrated to 10 mg/mL using an amicon ultra 10,000 MWCO centrifugal filter (Millipore, cat# UFC801096, lot# L3KN5251) and the buffer is changed to the formulation buffer used for adalimumab (5.57 mM sodium phosphate monobasic, 8.69 mM sodium phosphate dibasic, 106.69 mM NaCl, 1.07 mM sodium citrate, 6.45 mM citric acid, 66.68 mM mannitol, pH 5.2, 0.1% (w/v) Tween). The samples are mixed on a shaker at room temperature for 20 minutes. Then 180 mL of 100 mM Tris buffer, pH 8.1 is added to each sample and standard followed by the addition of 300 mL of 2 mM DTNB in 10 mM phosphate buffer, pH 8.1. After thorough mixing, the samples and standards are measured for absorption at 412 nm on a Cary 50 spectrophotometer. The standard curve is obtained by plotting the amount of free SH and OD₄₁₂ nm of the b-ME standards. Free SH content of samples are calculated based on this curve after subtraction of the blank.

Weak Cation Exchange Chromatography

[0261] Antibody or DVD-Ig protein is diluted to 1 mg/mL with 10 mM sodium phosphate, pH 6.0. Charge heterogeneity is analyzed using a Shimadzu HPLC system with a WCX-10 ProPac analytical column (Dionex, cat# 054993, S/N 02722). The samples are loaded on the column in 80% mobile phase A (10 mM sodium phosphate, pH 6.0) and 20% mobile phase B (10 mM sodium phosphate, 500 mM NaCl, pH 6.0) and eluted at a flow rate of 1.0 mL/minute.

Oligosaccharide Profiling

[0262] Oligosaccharides released after PNGase F treatment of antibody or DVD-Ig protein are derivatized with 2-aminobenzamide (2-AB) labeling reagent. The fluorescent-labeled oligosaccharides are separated by normal phase high performance liquid chromatography (NPHPLC) and the different forms of oligosaccharides are characterized based on retention time comparison with known standards.

[0263] The antibody or DVD-Ig protein is first digested with PNGaseF to cleave N-linked oligosaccharides from the Fc portion of the heavy chain. The antibody or DVD-Ig protein (200 mg) is placed in a 500 mL Eppendorf tube along with 2 mL PNGase F and 3 mL of 10% N-octylglucoside. Phosphate buffered saline is added to bring the final volume to 60 mL. The sample is incubated overnight at 37°C in an Eppendorf thermomixer set at 700 RPM. Adalimumab lot AFP04C is also digested with PNGase F as a control.

[0264] After PNGase F treatment, the samples are incubated at 95°C for 5 minutes in an Eppendorf thermomixer set at 750 RPM to precipitate out the proteins, then the samples are placed in an Eppendorf centrifuge for 2 minutes at 10,000 RPM to spin down the precipitated proteins. The supernatant containing the oligosaccharides are transferred to a 500 mL Eppendorf tube and dried in a speed-vac at 65°C.

[0265] The oligosaccharides are labeled with 2AB using a 2AB labeling kit purchased from Prozyme (cat# GKK-404, lot# 132026). The labeling reagent is prepared according to the manufacturer's instructions. Acetic acid (150 mL, provided in kit) is added to the DMSO vial (provided in kit) and mixed by pipeting the solution up and down several times. The acetic acid/DMSO mixture (100 mL) is transferred to a vial of 2-AB dye (just prior to use) and mixed until the dye is fully dissolved. The dye solution is then added to a vial of reductant (provided in kit) and mixed well (labeling reagent). The labeling reagent (5 mL) is added to each dried oligosaccharide sample vial, and mixed thoroughly. The reaction vials are placed in an Eppendorf thermomixer set at 65°C and 700-800 RPM for 2 hours of reaction.

[0266] After the labeling reaction, the excess fluorescent dye is removed using GlycoClean S Cartridges from Prozyme (cat# GKI-4726). Prior to adding the samples, the cartridges are washed with 1 mL of milli-Q water followed with 5 washes of 1 mL 30% acetic acid solution. Just prior to adding the samples, 1 mL of acetonitrile (Burdick and Jackson, cat# AH015-4) is added to the cartridges.

[0267] After all of the acetonitrile passes through the cartridge, the sample is spotted onto the center of the freshly washed disc and allowed to adsorb onto the disc for 10 minutes. The disc is washed with 1 mL of acetonitrile followed by five washes of 1 mL of 96% acetonitrile. The cartridges are placed over a 1.5 mL Eppendorf tube and the 2-AB labeled oligosaccharides are eluted with 3 washes (400 mL each wash) of milli Q water.

[0268] The oligosaccharides are separated using a Glycosep N HPLC (cat# GKI-4728) column connected to a Shimadzu HPLC system. The Shimadzu HPLC system consisted of a system controller, degasser, binary pumps, autosampler with a sample cooler, and a fluorescent detector.

Stability at Elevated Temperatures

[0269] The buffer of antibody or DVD-Ig protein is either 5.57 mM sodium phosphate monobasic, 8.69 mM sodium phosphate dibasic, 106.69 mM NaCl, 1.07 mM sodium citrate, 6.45 mM citric acid, 66.68 mM mannitol, 0.1% (w/v) Tween, pH 5.2; or 10 mM histidine, 10 mM methionine, 4% mannitol, pH 5.9 using Amicon ultra centrifugal filters. The final concentration of the antibodies or DVD-Ig proteins is adjusted to 2 mg/mL with the appropriate buffers. The antibody or DVD-Ig protein solutions are then filter sterilized and 0.25 mL aliquots are prepared under sterile conditions. The aliquots are left at either -80°C, 5°C, 25°C, or 40°C for 1, 2 or 3 weeks. At the end of the incubation period, the samples are analyzed by size exclusion chromatography and SDS-PAGE.

[0270] The stability samples are analyzed by SDS-PAGE under both reducing and non-reducing conditions. The procedure used is the same as described herein. The gels are stained overnight with colloidal blue stain (Invitrogen cat# 46-7015, 46-7016) and destained with Milli-Q water until the background is clear. The stained gels are then scanned using an Epson Expression scanner (model 1680, S/N DASX003641). To obtain more sensitivity, the same gels are silver stained using silver staining kit (Owl Scientific) and the recommended procedures given by the manufacturer is used.

Dynamic Scanning Fluorimetry

[0271] The DVD-Igs proteins were dialysed in 10mM citrate 10mM phosphate buffer, pH 6.0 to get a final concentration of 1 mg/ml. Triplicates were run for each DVD-Ig protein. For each sample, 27 µl of the DVD-Ig protein was added in a well of a 96 well plate and mixed with 3 µl of 4X diluted SYPRO Orange dye (Invitrogen). The dye is supplied in DMSO at a concentration of 5000X and was diluted to the working concentration of 4X in water. The plate was centrifuged for 30 seconds to ensure that both the dye and the protein settle to the bottom of the wells and complete mixing was ensured by gentle aspiration by a pipette tip. The plate was then sealed with an adhesive film.

[0272] A real time PCR (Applied Biosciences, 7500 Series) was used for measuring the change in fluorescence intensities with temperature. The plate was heated from 25° C to 95° C at a temperature ramp rate of approximately 0.5°C/minute and emission fluorescence was collected using TAMRA filter. The data was exported to Microsoft Excel and plotted as temperature vs fluorescence for each DVD-Ig protein. Onset of melting was noted as the temperature where the thermogram rises above the baseline fluorescence. SYPRO Orange is a hydrophobic dye and preferentially binds to the exposed hydrophobic residues in an unfolded protein molecule. Hence the onset of unfolding temperature, as measured by an increase in fluorescence, is an indication of the thermal stability of the DVD-Ig protein. The unfolding temperature for the DVD-Ig proteins can be found in Table 8.

Table 8: Thermal Stability of DVD-Ig Proteins as Determined by Dynamic Scanning Fluorimetry

Parent Antibody or DVD-Ig ID	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	T onset (deg C)
DVD3415	IL-1b (seq 1)	IL-17 (seq 2)	63.3
DVD3416	IL-1b (seq 3)	IL-17 (seq 3)	60.9
DVD3417	IL-1b (seq 1)	IL-17 (seq 3)	65.8
DVD3418	IL-1b (seq 2)	IL-17 (seq 2)	63.9
DVD3419	IL-1b (seq 3)	IL-17 (seq 3)	60.8
DVD3420	IL-1b (seq 1)	IL-17 (seq 3)	65.2
DVD3423	IL-1b (seq 3)	IL-17 (seq 3)	60.5
DVD3424	IL-1b (seq 5)	IL-17 (seq 3)	58.6
DVD3425	IL-1b (seq 5)	IL-17 (seq 3)	58.7
AB274	IL-17 (seq 4)	NA	61
AB420	IL-17 (seq 3)	NA	54

[0273] Most DVD-Ig proteins showed an unfolding temperature >50 degrees C. This DVD-Ig protein profile is similar to that observed for parent antibodies.

Solubility Determination

[0274] DVD-Ig protein candidates were dialyzed in 15mM His, pH 6.0. This was followed by concentrating them upto 50 µl in centricons with a 30K cutoff. Solubility was visually confirmed by absence of precipitation after storage at 4°C and quantitatively determined by UV absorbance measurement at 280nm. See Table 9 ("ppt" indicates precipitation).

Table 9: Solubility of DVD-Ig Proteins

Parent Antibody or DVD-Ig ID	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	Visual observation	Solubility (mg/mL)
DVD3410	IL-1b (seq 1)	IL-17 (seq 1)	clear	>86.5
DVD3411	IL-1b (seq 2)	IL-17 (seq 1)	ppt	
DVD3412	IL-1b (seq 3)	IL-17 (seq 1)	ppt	
DVD3413	IL-1b (seq 4)	IL-17 (seq 1)	ppt	
DVD3414	IL-1b (seq 5)	IL-17 (seq 1)	ppt	
DVD3415	IL-1b (seq 1)	IL-17 (seq 2)	clear	>163.6
DVD3416	IL-1b (seq 3)	IL-17 (seq 3)	clear	>169.6
DVD3417	IL-1b (seq 1)	IL-17 (seq 3)	clear	>91.6
DVD3418	IL-1b (seq 2)	IL-17 (seq 2)	clear	>129.6
DVD3419	IL-1b (seq 3)	IL-17 (seq 3)	clear	>168.2
DVD3420	IL-1b (seq 1)	IL-17 (seq 3)	clear	>60.3
DVD3421	IL-1b (seq 4)	IL-17 (seq 3)	phase separation	
DVD3422	IL-1b (seq 2)	IL-17 (seq 3)	clear	>35
DVD3423	IL-1b (seq 3)	IL-17 (seq 3)	clear	>149.6
DVD3424	IL-1b (seq 5)	IL-17 (seq 3)	clear	>142.7
DVD3425	IL-1b (seq 5)	IL-17 (seq 3)	clear	>136
AB274	IL-17 (seq 4)	NA	Clear	>65.5
AB420	IL-17 (seq 2)	NA	Clear	>181

[0275] Most DVD-Ig proteins showed clear appearance and could be concentrated to greater than 25 mg/ml. This DVD-Ig protein profile is similar to that observed for parent antibodies.

Example 4: Screening Funnel

[0276] In an effort to generate IL-1 β /IL-17 DVD-Ig binding proteins with drug-like properties, a large panel of DVD-Ig binding proteins was generated, including DVD-Ig binding proteins containing one of five different anti-IL-1 β variable domains (E26.13, E26.35, 1B12.1, 1B12.3, 1B12.6), one of three different anti-IL-17 variable domains (10F7M11, B6-5, B6-17), one of three different linker combinations (SS, LS, SL), and one of two orientations (i.e., IL-17 as the inner or outer variable domain binding site) were made and screened by size exclusion chromatography (SEC), affinity, potency and preformulation analysis. None of the DVD-Ig binding proteins achieved the desired threshold for all the preformulation criteria.

[0277] Based on the information from the initial screening of DVD-Ig binding proteins, a small panel of additional DVD-Ig binding proteins was prepared. DVD-Ig binding proteins contained anti-IL-1 β variable domains E26.13 or E26.35 and anti-IL-

17 variable domains B6-5G or B6-17G, an X1 linker on both the heavy and light chains comprising Gly-Ser repeats (referred to as a "GS" linker), and only one orientation (inner variable domains forming a binding site for: IL-17 and outer variable domains forming a binding site for: IL-1 β). The anti-IL-17 variable domains (B6-5G, B6-17G) were engineered from prior IL-17 variable domains B6-5 and B6-17, with an N to G mutation at HC-CDR3 to eliminate a deamidation site. The DVD-Ig binding proteins were screened in an IL-1 β potency assay for IL-8 release in a human foreskin fibroblast MRC-5 cell line, and in an IL-17 potency assay for IL-6 release in human fetal lung fibroblast HS27 cells. As shown in Table 10, DVD3415 and DVD3418 exhibited high potency in neutralizing both IL-1 β and IL-17 activity, with IC₅₀ at low pM range. The data provided in Table 10 reflects mean +/- standard deviation from 2 experiments for IL-1 β and from 3-4 experiments for IL-17. Of the tested DVD-Ig binding proteins, DVD3415 and DVD3418 exhibited IL-17 potency values that were closest to the parental antibodies.

Table 10: IL-1 β and IL-17 potency of selected DVD-Ig binding proteins

Ab Name	N-terminal Variable Domain	C-terminal Variable Domain	Linker	IL-1 β Potency IC ₅₀ (pM) ^a	IL-17 Potency IC ₅₀ (pM) ^b
DVD3415	IL-1 β (E26.13)	IL-17 (B6-17G)	GS	8 $\pm$ 0.6	70 $\pm$ 30
DVD3417	IL-1 β (E26.13)	IL-17 (B6-5G)	GS	6 $\pm$ 3	398 $\pm$ 124
DVD3418	IL-1 β (E26.35)	IL-17 (B6-17G)	GS	3 $\pm$ 1	60 $\pm$ 24
DVD3422	IL-1 β (E26.35)	IL-17 (B6-5G)	SL	1 $\pm$ 0.2	149 $\pm$ 103
AB268	IL-1 β (E26.13)			10	
AB269	IL-1 β (E26.35)			2	
AB274	IL-17 (B6-17G)				2
AB275	IL-17 (B6-5G)				3

[0278] Further evaluation of the physicochemical properties of the DVD-Ig binding proteins from Table 10 demonstrated that DVD3415 and DVD3418 exhibited properties above a desired threshold for each preformulation criteria (see Table 11). DVD3415 and DVD3418 were stable at high concentration in a liquid formulation of 15mM histidine, pH 5.5.

	Viscosity/ Turbidity (cP)	T _m (DSC) (°C)	Freeze/Thaw Stability % HMW increase post 4 F/T at 1 mg/mL	Accel. Stability Monomer Loss at 40°C, T21d 1 mg/mL	Freeze/Thaw Stability % HMW increase post 4 F/T at 100 mg/mL	Accel. Stability Mono. Loss at T21d 100 mg/mL		4°C Stability Monomer Loss at T21d 100 mg/mL
						@25°C	@40°C	
DVD 3415	5.08	58	0.15	1.6	0.58	0.86	2.87	0.8
DVD 3417	2.81	57	0.49	1.9	0.94	0.77	2.96	0.82
DVD 3418	5.28	58	0.31	1.87	0.07	0.98	1.82	0.85 @ T28d
DVD 3422	Gel at 4°C	57	0.01	1.55	19.48	12.82	8.78	19.88 gelling
Criteria	< 10 cP	T _m > 50°C	< 0.5% HMW increase after 4 F/T cycles	< 3% monomer loss at 40°C, T21d	< 0.5% HMW increase after 4 F/T cycles	< 5% monomer loss at 40°C, T21d		< 1% monomer loss at 40°C, T21d

Development Risk – Color Code:  Low risk  Medium risk  High risk

Table 11: Physicochemical properties of selected DVD-Ig binding proteins

[0279] Both DVD3415 and DVD3418 were shown to be stable molecules with high potency and desirable physicochemical properties. Both share the same anti-IL-17 variable region (B6-17G) and a similar anti-IL-1 β variable region (E26.13 in DVD3415 and E26.35 in DVD3418). E26.35 only differs from E26.13 in the heavy chain (HC) by 4 amino acid residues (one in CDR3 and 3 in FR3). Surprisingly, DVD3418, containing E26.35 as its anti-IL-1 β domain, exhibited higher potency and possessed more germline sequences as compared to DVD3415, containing E26.13 as its anti-IL-1 β domain. Thus, DVD3418 was selected for further evaluation.

[0280] Accordingly, additional formulation testing was performed for DVD3418. When formulated in 15 mM histidine, pH 5.5, a dose of 100 mg/ml DVD3418 exhibited favorable physicochemical characteristics, including solubility, viscosity, and stability on freeze thaw. Onset of melting (i.e., unfolding) of the DVD-Ig was measured using differential scanning calorimetry (DSC). Freeze/thaw stability was measured by evaluating the percentage increase in high molecular weight (HMW) products after four rounds of freeze thaw. Accelerated stability was evaluated by measuring monomer loss after incubation for 21-28 days at 25°C and 40°C. The physicochemical properties of DVD3418 are summarized in Table 12 below, and compared against threshold criteria for each property (cP = centipoise, T_{on} = melting temperature).

Table 12

	Viscosity/ Turbidity (cP)	T _{on} (°C)	Freeze/Thaw Stability at 1 mg/ml	Accel. Stability (40°C) at 1 mg/ml
DVD3418	5.26	56	0.31	1.67
Threshold Criteria	<10cP	T _{on} >50°C	<0.5% increase in HMW products	<3% monomer loss

	Freeze/Thaw Stability at 100 mg/ml	Accel. Stability monomer loss at 100 mg/ml		4°C Stability at 100 mg/ml
		25°C	40°C	
DVD3418	0.07	0.98	1.82	-0.85 (day 28)
Threshold Criteria	<0.5% increase in HMW products	<5% monomer loss	<5% monomer loss	<1% monomer loss

[0281] The data in Table 12 demonstrate no significant changes to the DVD-Ig binding protein during thermal stress (e.g., incubation at 40°C for 21 days), suggesting the DVD-Ig binding protein may be formulated as a stable high concentration liquid formulation.

[0282] Although DVD3418 shares an identical anti-IL-1 β variable domain (E26.35) and a similar anti-IL-17 variable domain (only one amino acid difference between B6-17G in DVD3418 and B6-17 in others) with a few other DVD-Ig binding proteins (e.g., DVD1274, DVD1601, DVD1631 and DVD1661), DVD13418 exhibited superior solubility and stability, whereas the other DVD-Ig binding proteins either exhibited a reduced level of host cell expression (e.g., DVD1661) or less superior physicochemical properties (e.g., DVD1274, 1601, 1631) (see Table 13). These other DVD-Ig binding proteins all have different linker sequences, and linker sequences can affect the physicochemical properties of a binding protein, since the overall sequence, including the variable domains and the linker, may determine the physicochemical properties of a DVD-Ig molecule.

Table 13: Comparison of DVD-Ig binding protein physicochemical properties

DVD-Ig	N-terminal Variable Domain (VD)	C-terminal Variable Domain (VD)	Linker	hlgG1 Fc	IL-1 β Potency IC ₅₀ (pM)	IL-17 Potency IC ₅₀ (pM)	Physicochemical Property
DVD3418	IL-1 β (E26.35)	IL-17 (B6-17G)	GS	Fc mut (234,235)	11 $\pm$ 10	60 $\pm$ 16	Achieved all preformulation criteria
DVD1274	IL-1 β (E26.35)	IL-17 (B6-17)	SS	wt Fc	7	1081	Reduced solubility (observed opalescence at 4°C)
DVD1275	IL-17 (B6-17)	IL-1 β (E26.35)	SS	wt Fc	1916	1	Reduced IL-1 β potency
DVD1601	IL-1 β (E26.35)	IL-17 (B6-17)	SL	wt Fc	4	26	Reduced stability after freeze/thaw and some phase separation at high concentration
DVD1602	IL-17 (B6-17)	IL-1 β (E26.35)	SL	wt Fc	133	3	Reduced IL-1 β potency
DVD1631	IL-1 β (E26.35)	IL-17 (B6-17)	LS	wt Fc	4	460	Reduced stability at 4°C and reduced in vitro serum stability
DVD1632	IL-17 (B6-17)	IL-1 β (E26.35)	LS	wt Fc	438	7	Reduced IL-1 β potency
DVD1661	IL-1 β (E26.35)	IL-17 (B6-17)	LL	wt Fc	Not evaluated due to low expression		
DVD1662	IL-17 (B6-17)	IL-1 β (E26.35)	LL	wt Fc	Not evaluated due to low expression		

[0283] DVD3418 is also selective for primate IL-1 β and IL-17 over antigens from other species. DVD3418 neutralized cyno monkey IL-1 β at comparable potency to human IL-1 β , rabbit IL-1 β at ~100-fold less potency, mouse IL-1 β at ~1000-fold less potency, and failed to neutralize rat IL-1 β at the highest test concentration 500 nM (see Table 14). DVD3418 also neutralized cyno monkey IL-17 with an IC₅₀ within a 2-fold range of human IL-17, rabbit IL-17 with ~50-fold less potency, and rat and mouse IL-17 with at least 200-fold less potency, as compared to human IL-17 (see Table 14).

Table 14: species cross-reactivity of DVD3418

Antigen Species	IL-1 β Potency (IC ₅₀) ^a	IL-17 Potency (IC ₅₀) ^b
Human	11 $\pm$ 10	60 $\pm$ 16

Cyno monkey	7 ± 5	163 ± 41
Mouse	11200 ± 12300	>50000
Rat	NR	12000 ± 5600
Rabbit	1400 ± 1200	2900 ± 1800

NR: no activity up to highest test concentration (500 nM) .

^aIL-1 β potency was determined by IL-8 release assay in a human foreskin fibroblast MRC-5 cell line.

^bIL-17 potency was determined by IL-6 release assay in a human fetal lung fibroblast HS27 cell line.

Example 5: In vivo testing

[0284] DVD3418 was tested for half-life and immunogenicity in rat and cynomolgus monkey. The pharmacokinetic parameters after intravenous administration of a 5mg/kg dose to Sprage Dawley rats are shown in Table 15 below ($t_{1/2}$ = half life, C_{max} = maximum serum concentration, V_{ss} = volume of distribution at steady state, AUC = area under curve, CL_p = plasma clearance, MRT = mean residence time). DVD3418 displayed a long half-life (approximately 10 days), a moderate CL (approximately 0.37 ml/h/kg), and a small V_{ss} (approximately 113 ml/kg). One animal was omitted when determining these averages due to probable ADA.

Table 15

Rat #	$t_{1/2}$ (hr)	C_{max} (ug/mL)	V_{ss} (L/kg)	AUC (ug·hr/mL)	AUC ₀₋₁ (ug·hr/mL)	CL_p (L/hr/kg)	MRT (hr)
1	270	95.0	0.118	14200	11900	0.000353	335
2	240	115	0.0898	17200	14900	0.000292	308
4	220	107	0.117	12000	10600	0.000415	281
5	260	98.5	0.129	12500	10600	0.000401	322
Mean	240	104	0.113	14000	12000	0.000365	311
SEM		4.57	0.0083	1160	1010	0.0000279	11.6

[0285] DVD3418 was also administered intravenously to cynomolgus monkeys and serum samples collected over a 700 hour period. DVD3418 exhibited a long half-life, a low clearance rate, and a small V_{ss} ; no apparent ADA (anti-drug antibodies) were observed. Based on this, the DVD-Ig binding protein may be suitable for less frequent dosing without requiring further half-life extending mutations.

[0286] Heavy and light chain sequences of several DVD-Ig binding proteins mentioned above are provided in Table 16. The parental antibody variable domains

used to prepare the inner and outer variable domains of the binding proteins are also identified. The X1 linker sequences are underlined.

Table 16

SEQ ID NO	DVD Variable Domain Name	Outer Variable Domain Name	Inner Variable Domain Name	Sequence
	DVD1274H	AB269VH	AB274VH	12345678901234567890123456789012345 EVQLVESGGGVVQPGKSLRLSCSASGFTIFSRYDMS WVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTI SRDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGY FDVWGQGTPTVTSSASTKGPVQLVQSGAEVKKPG SSVKVSCKASGGSFGGYGIGWVRQAPGQGLEWMGG ITPFFGFADYAQKFQGRVTITADESTTTAYMELSG LTSDDTAVYYCARDPNEFWNGYYSTHDFDSWGQGT TVTVSS
	DVD1274L	AB269VL	AB274VL	DIQMTQSPSSLSASVGDRTITCRASGNIHNYLTW YQQTTPGKAPKLLIYNAKTLADGVPSRFSGSGSGTD YTFTISSLPEDIATYYCQHFWSIPYTFGQGTKLQ ITRTVAAPFIVLTQSPDFQSVTPKEKVTITCRASQ DIGSELHWYQQKPDQPPKLLIKYASHSTSGVPSRF SGSGSGTDFTLTINGLEAEADAGTYTCHQTDLSLPYT FGPGTKVDIKR
	DVD1275H	AB274VH	AB269VH	EVQLVQSGAEVKKPGSSVKVSCKASGGSFGGYGIG WVRQAPGQGLEWMGGITPFFGFADYAQKFQGRVTI TADESTTTAYMELSGLTSDDTAVYYCARDPNEFWN GYYSTRDFDSWGQGTPTVTSSASTKGPVQLVESG GGVVQPGKSLRLSCSASGFTIFSRYDMSWVRQAPGK GLEWVAYISHGGAGTYYPDSVKGRFTISRDNSKNT LFLQMDSLRAEDTAVYYCARGGVYKGYFDVWGQGT PVTVSS
	DVD1275L	AB274VL	AB269VL	EIVLTQSPDFQSVTPKEKVTITCRASQDIGSELHW YQQKPDQPPKLLIKYASHSTSGVPSRFSGSGSGTD FTLTINGLEAEADAGTYTCHQTDLSLPYTFGPGTKVD IKRTVAAPDIQMTQSPSSLSASVGDRTITCRASG NIHNYLTWYQQTTPGKAPKLLIYNAKTLADGVPSRF SGSGSGTDYFTFTISSLPEDIATYYCQHFWSIPYT FGQGTKLQITR
	DVD1601H	AB269VH	AB274VH	EVQLVESGGGVVQPGKSLRLSCSASGFTIFSRYDMS WVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTI SRDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGY FDVWGQGTPTVTSSASTKGPVQLVQSGAEVKKPG SSVKVSCKASGGSFGGYGIGWVRQAPGQGLEWMGG ITPFFGFADYAQKFQGRVTITADESTTTAYMELSG LTSDDTAVYYCARDPNEFWNGYYSTHDFDSWGQGT TVTVSS
	DVD1601L	AB269VL	AB274VL	DIQMTQSPSSLSASVGDRTITCRASGNIHNYLTW YQQTTPGKAPKLLIYNAKTLADGVPSRFSGSGSGTD YTFTISSLPEDIATYYCQHFWSIPYTFGQGTKLQ ITRTVAAPSVFIHPPEIVLTQSPDFQSVTPKEKVT ITCRASQDIGSELHWYQQKPDQPPKLLIKYASHST SGVPSRFSGSGSGTDFTLTINGLEAEADAGTYTCHQ TDSLPYTFGPGTKVDIKR
	DVD1602H	AB274VH	AB269VH	EVQLVQSGAEVKKPGSSVKVSCKASGGSFGGYGIG WVRQAPGQGLEWMGGITPFFGFADYAQKFQGRVTI TADESTTTAYMELSGLTSDDTAVYYCARDPNEFWN GYYSTHDFDSWGQGTPTVTSSASTKGPVQLVESG GGVVQPGKSLRLSCSASGFTIFSRYDMSWVRQAPGK GLEWVAYISHGGAGTYYPDSVKGRFTISRDNSKNT LFLQMDSLRAEDTAVYYCARGGVYKGYFDVWGQGT PVTVSS

	DVD1602L	AB274VL	AB269VL	EIVLTQSPDFQSVTPKEKVTITCRASQDIGSELHW YQOKPDQPPKLLIKYASHSTSGVPSRFSGSGSGTD FTLTINGLEAEADAGTYYYCHQTDLSLPTYTFGPGTKVD IKRTVAAPSVFIFFPDIQMTQSPSSLSASVGDRT ITCRASGNIHNYLTWYQQTGKAPKLLIYNAKT DGVPSRFSGSGSGTDYTFITSSLOPEDATYYCQH FWSIPYTFGQGTKLQITR
	DVD1631H	AB269VR	AB274VR	EVQLVESGGGVVQPGSRSLRLSCSASGFI FGRYDMSWVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTI SRDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGY FDVWGQGTPTVTVSSASTKGPSVFPLAPEVQLVQSG AEVKKPESSVKVSCKASGGSFSGYGI GWVRQAPGQGLEWMGGITPFFGFADYAKQFQGRVTITADESTTT AYMELSGLTSDDTAVYYCARDPNEFWNGYYSTHDF DSWGQGTPTVTVSS
	DVD1631L	AB269VL	AB274VL	DIQMTQSPSSLSASVGDRTITCRASGNIHNYLTW YQQTGKAPKLLIYNAKTLDGVPSRFSGSGSGTD YTFITSSLOPEDATYYCQHFWSIPYTFGQGT KLQITRTVAAPSVFIFFPEIVLTQSPDFQSVTPKEKVTITCRASQ DIGSELHWYQOKPDQPPKLLIKYASHSTSGVPSR FSGSGSGTDFTLTINGLEAEADAGTYYYCHQTDLSLPTY FGPGTKVDIKR
	DVD1632H	AB274VR	AB269VR	EVQLVQSGAEVKKPESSVKVSCKASGGSFSGYGI GIGWVRQAPGQGLEWMGGITPFFGFADYAKQFQGRVTI TADESTTTAYMELSGLTSDDTAVYYCARDPNEFWN GYSTHDFDSWGQGTPTVTVSSASTKGPSVFPLAPE VQLVESGGGVVQPGSRSLRLSCSASGFI FSRYDMSWVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTIS RDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGYF DVWGQGTPTVTVSS
	DVD1632L	AB274VL	AB269VL	EIVLTQSPDFQSVTPKEKVTITCRASQDIGSELHW YQOKPDQPPKLLIKYASHSTSGVPSRFSGSGSGTD FTLTINGLEAEADAGTYYYCHQTDLSLPTYTFGPGTKVD IKRTVAAPDIQMTQSPSSLSASVGDRTITCRASG NIHNYLTWYQQTGKAPKLLIYNAKTLDGVPSR FSGSGSGTDYTFITSSLOPEDATYYCQHFWSIPY TFGQGTKLQITR
	DVD1661H	AB269VR	AB274VR	EVQLVESGGGVVQPGSRSLRLSCSASGFI FSRYDMSWVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTI SRDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGY FDVWGQGTPTVTVSSASTKGPSVFPLAPEVQLVQSG AEVKKPESSVKVSCKASGGSFSGYGI GWVRQAPGQGLEWMGGITPFFGFADYAKQFQGRVTITADESTTT AYMELSGLTSDDTAVYYCARDPNEFWNGYYSTHDF DSWGQGTPTVTVSS
	DVD1661L	AB269VL	AB274VL	DIQMTQSPSSLSASVGDRTITCRASGNIHNYLTW YQQTGKAPKLLIYNAKTLDGVPSRFSGSGSGTD YTFITSSLOPEDATYYCQHFWSIPYTFGQGT KLQITRTVAAPSVFIFFPEIVLTQSPDFQSVTPKEKVT ITCRASQDIGSELHWYQOKPDQPPKLLIKYASHST SGVPSRFSGSGSGTDFTLTINGLEAEADAGTYYYCHQ TDSLPTYTFGPGTKVDIKR
	DVD1662H	AB274VR	AB269VR	EVQLVQSGAEVKKPESSVKVSCKASGGSFSGYGI GIGWVRQAPGQGLEWMGGITPFFGFADYAKQFQGRVTI TADESTTTAYMELSGLTSDDTAVYYCARDPNEFWN GYSTHDFDSWGQGTPTVTVSSASTKGPSVFPLAPE VQLVESGGGVVQPGSRSLRLSCSASGFI FSRYDMSWVRQAPGKGLEWVAYISHGGAGTYYPDSVKGRFTIS RDNSKNTLFLQMDSLRAEDTAVYYCARGGVYKGYF DVWGQGTPTVTVSS
	DVD1662L	AB274VL	AB269VL	EIVLTQSPDFQSVTPKEKVTITCRASQDIGSELHW YQOKPDQPPKLLIKYASHSTSGVPSRFSGSGSGTD FTLTINGLEAEADAGTYYYCHQTDLSLPTYTFGPGTKVD IKRTVAAPSVFIFFPDIQMTQSPSSLSASVGDRT

				ITCPASGNIARNYLTWYQQTPGKAPKLLIYNAKTLA DGVPSRPFSGSGSGTDYTFITISLQPEDATYYCQH FWSIPYTFGQGTKLQITR
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Incorporation by Reference

[0287] The contents of all cited references (including literature references, patents, patent applications, and websites) that maybe cited throughout this application are hereby expressly incorporated by reference in their entirety for any purpose, as are the references cited therein. The disclosure will employ, unless otherwise indicated, conventional techniques of immunology, molecular biology and cell biology, which are well known in the art.

[0288] The present disclosure also incorporates by reference in their entirety techniques well known in the field of molecular biology and drug delivery. These techniques include, but are not limited to, techniques described in the following publications:

Ausubel et al. (eds.), CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons, NY (1993);

Ausubel, F.M. et al. eds., SHORT PROTOCOLS IN MOLECULAR BIOLOGY (4th Ed. 1999) John Wiley & Sons, NY. (ISBN 0-471-32938-X);

CONTROLLED DRUG BIOAVAILABILITY, DRUG PRODUCT DESIGN AND PERFORMANCE, Smolen and Ball (eds.), Wiley, New York (1984);

Giege, R. and Ducruix, A. Barrett, CRYSTALLIZATION OF NUCLEIC ACIDS AND PROTEINS, a Practical Approach, 2nd ea., pp. 20 1-16, Oxford University Press, New York, New York, (1999);

Goodson, in MEDICAL APPLICATIONS OF CONTROLLED RELEASE, vol. 2, pp. 115-138 (1984);

Hammerling, et al., in: MONOCLONAL ANTIBODIES AND T-CELL HYBRIDOMAS 563-681 (Elsevier, N.Y., 1981;

Harlow et al. , ANTIBODIES: A LABORATORY MANUAL, (Cold Spring Harbor Laboratory Press, 2nd ed. 1988);

Kabat et al., SEQUENCES OF PROTEINS OF IMMUNOLOGICAL INTEREST (National Institutes of Health, Bethesda, Md. (1987) and (1991);

Kabat, E.A., et al. (1991) SEQUENCES OF PROTEINS OF IMMUNOLOGICAL INTEREST, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242;

Kontermann and Dubel eds., ANTIBODY ENGINEERING (2001) Springer-Verlag. New York. 790 pp. (ISBN 3-540-41354-5).

Kriegler, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY (1990);

Lu and Weiner eds., CLONING AND EXPRESSION VECTORS FOR GENE FUNCTION ANALYSIS (2001) BioTechniques Press. Westborough, MA. 298 pp. (ISBN 1-881299-21-X).

MEDICAL APPLICATIONS OF CONTROLLED RELEASE, Langer and Wise (eds.), CRC Pres., Boca Raton, Fla. (1974);

Old, R.W. & S.B. Primrose, PRINCIPLES OF GENE MANIPULATION: AN INTRODUCTION TO GENETIC ENGINEERING (3d Ed. 1985) Blackwell Scientific Publications, Boston. Studies in Microbiology; V.2:409 pp. (ISBN 0-632-01318-4).

Sambrook, J. et al. eds., MOLECULAR CLONING: A LABORATORY MANUAL (2d Ed. 1989) Cold Spring Harbor Laboratory Press, NY. Vols. 1-3. (ISBN 0-87969-309-6).

SUSTAINED AND CONTROLLED RELEASE DRUG DELIVERY SYSTEMS, J.R. Robinson, ed., Marcel Dekker, Inc., New York, 1978

Winnacker, E.L. FROM GENES TO CLONES: INTRODUCTION TO GENE TECHNOLOGY (1987) VCH Publishers, NY (translated by Horst Ibelgauf). 634 pp. (ISBN 0-89573-614-4).

Equivalents

[0289] The disclosure may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting of the disclosure. Scope of the disclosure is thus indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced herein.

We claim:

1. A binding protein comprising first and second polypeptide chains, each independently comprising VD1-(X1)_n-VD2-C-X2, wherein

VD1 is a first variable domain;

VD2 is a second variable domain;

C is a constant domain;

X1 is a linker with the proviso that it is not CH1;

X2 is an Fc region that is either present or absent;

n is 0 or 1,

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein the binding protein is capable of binding IL-1 β and IL-17, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise:

CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35,

CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33,

CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3 from SEQ ID NO: 37,

CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, or

CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41;

and/or

the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC₅₀ of at most about 2.563 nM, as measured in an IL-1 β neutralization assay, and/or

(ii) the variable domains that form a functional target binding site for IL-17 comprise

CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45;

CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43; or

CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47;
and/or

the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, as measured in an IL-17 neutralization assay.

2. A binding protein comprising first and second polypeptide chains, each independently comprising VD1-(X1) n -VD2-C-X2, wherein

VD1 is a first variable domain;

VD2 is a second variable domain;

C is a constant domain;

X1 is a linker with the proviso that it is not CH1;

X2 is an Fc region that is either present or absent;

n is 0 or 1,

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein the binding protein is capable of binding IL-1 β and IL-17, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise a sequence selected from the group consisting of SEQ ID NOs: 32-41 and/or the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon

resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 2.563 nM, as measured in an IL-1 β neutralization assay, and/or

(ii) the variable domains that form a functional target binding site for IL-17 comprise a sequence selected from the group consisting of SEQ ID NO: 42-47, and/or the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, as measured in an IL-17 neutralization assay.

3. The binding protein of claim 1 or 2, wherein the first polypeptide chain comprises a first VD1-(X1) n -VD2-C-X2, wherein

VD1 is a first heavy chain variable domain;

VD2 is a second heavy chain variable domain;

C is a heavy chain constant domain;

X1 is a linker with the proviso that it is not CH1;

X2 is an Fc region that is either present or absent;

n is 0 or 1, and

wherein the second polypeptide chain comprises a second VD1-(X1) n -VD2-C,

wherein

VD1 is a first light chain variable domain;

VD2 is a second light chain variable domain;

C is a light chain constant domain;

X1 is a linker with the proviso that it is not CH1;

n is 0 or 1,

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site.

4. The binding protein of any one of claims 1-3, wherein the binding protein is capable of binding IL-1 β and IL-17, and wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise:

- (1) SEQ ID NO: 32 and SEQ ID NO: 33,
- (2) SEQ ID NO: 34 and SEQ ID NO: 35,
- (3) SEQ ID NO: 36 and SEQ ID NO: 37,
- (4) SEQ ID NO: 38 and SEQ ID NO: 39, or
- (5) SEQ ID NO: 40 and SEQ ID NO: 41; and/or

(ii) the variable domains that form a functional target binding site for IL- 17 comprise:

- (1) SEQ ID NO: 42 and SEQ ID NO: 43,
- (2) SEQ ID NO: 44 and SEQ ID NO: 45, or
- (3i) SEQ ID NO: 46 and SEQ ID NO: 47.

5. The binding protein of any one of claims 1-4, comprising two first polypeptide chains and two second polypeptide chains, wherein the binding protein comprises four functional target binding sites.

6. The binding protein of any one of claims 1-5, wherein X1 is any one of SEQ ID NO: 1-31.

7. The binding protein of any one of claims 1-6, wherein X1 is not CL.

8. The binding protein of any one of claims 1-7, wherein the Fc region is a variant sequence Fc region.

9. The binding protein of any one of claims 1-8, wherein the Fc region is an Fc region from an IgG1, IgG2, IgG3, IgG4, IgA, IgM, IgE, or IgD.

10. The binding protein of any one of claims 1-9, wherein the binding protein is a crystallized binding protein.

11. A binding protein capable of binding IL-1 β and IL-17, wherein the binding protein comprises any one of: DVD2423 (comprising SEQ ID NOs: 48 and 49); DVD2424

(comprising SEQ ID NOs: 50 and 51); DVD2425 (comprising SEQ ID NOs: 52 and 53); DVD2426 (comprising SEQ ID NOs: 54 and 55); DVD2427 (comprising SEQ ID NOs: 56 and 57); DVD2428 (comprising SEQ ID NOs: 58 and 59); DVD2429 (comprising SEQ ID NOs: 60 and 61); DVD2430 (comprising SEQ ID NOs: 62 and 63); DVD2431 (comprising SEQ ID NOs: 64 and 65); DVD2432 (comprising SEQ ID NOs: 66 and 67); DVD2433 (comprising SEQ ID NOs: 68 and 69); DVD2434 (comprising SEQ ID NOs: 70 and 71); DVD2435 (comprising SEQ ID NOs: 72 and 73); DVD2436 (comprising SEQ ID NOs: 74 and 75); DVD2437 (comprising SEQ ID NOs: 76 and 77); DVD2438 (comprising SEQ ID NOs: 78 and 79); DVD2439 (comprising SEQ ID NOs: 80 and 81); DVD2440 (comprising SEQ ID NOs: 82 and 83); DVD2441 (comprising SEQ ID NOs: 84 and 85); DVD2442 (comprising SEQ ID NOs: 86 and 87); DVD3410 (comprising SEQ ID NOs: 88 and 89); DVD3411 (comprising SEQ ID NOs: 90 and 91); DVD3412 (comprising SEQ ID NOs: 92 and 93); DVD3413 (comprising SEQ ID NOs: 94 and 95); DVD3414 (comprising SEQ ID NOs: 96 and 97); DVD3415 (comprising SEQ ID NOs: 98 and 99); DVD3416 (comprising SEQ ID NOs: 100 and 101); DVD3417 (comprising SEQ ID NOs: 102 and 103); DVD3418 (comprising SEQ ID NOs: 104 and 105); DVD3419 (comprising SEQ ID NOs: 106 and 107); DVD3420 (comprising SEQ ID NOs: 108 and 109); DVD3421 (comprising SEQ ID NOs: 110 and 111); DVD3422 (comprising SEQ ID NOs: 112 and 113); DVD3423 (comprising SEQ ID NOs: 114 and 115); DVD3424 (comprising SEQ ID NOs: 116 and 117); and DVD3425 (comprising SEQ ID NOs: 118 and 119).

12. A binding protein conjugate comprising a binding protein according to any one of claims 1-11, the binding protein conjugate further comprising an immunoadhesion molecule, an imaging agent, a therapeutic agent, or a cytotoxic agent.

13. The binding protein conjugate of claim 12, wherein the imaging agent is a radiolabel, an enzyme, a fluorescent label, a luminescent label, a bioluminescent label, a magnetic label, or biotin.

14. The binding protein conjugate of claim 13, wherein said radiolabel is ^3H , ^{14}C , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I , ^{177}Lu , ^{166}Ho , or ^{153}Sm .

15. The binding protein conjugate of claim 12, wherein said therapeutic or cytotoxic agent is an anti-metabolite, an alkylating agent, an antibiotic, a growth factor, a cytokine, an anti-angiogenic agent, an anti-mitotic agent, an anthracycline, toxin, or an apoptotic agent.

16. An isolated nucleic acid encoding a binding protein amino acid sequence according to any one of claims 1-11.
17. A vector comprising an isolated nucleic acid according to claim 16.
18. The vector of claim 17, wherein the vector is pcDNA, pTT, pTT3, pEFBOS, pBV, pJV, pcDNA3.1 TOPO, pEF6, pHybE, TOPO, or pBJ.
19. A host cell comprising the vector of claim 17.
20. The host cell of claim 19, wherein the host cell is a prokaryotic cell, *Escherichia coli*, a eukaryotic cell, a protist cell, an animal cell, a plant cell, a fungal cell, a yeast cell, an Sf9 cell, a mammalian cell, an avian cell, an insect cell, a CHO cell or a COS cell.
21. A method of producing a binding protein, comprising culturing the host cell of claim 19 or 20 in culture medium under conditions sufficient to produce the binding protein.
22. A pharmaceutical composition comprising the binding protein according to any one of claims 1-11, and a pharmaceutically acceptable carrier.
23. The pharmaceutical composition of claim 22, further comprising at least one additional therapeutic agent.
24. The pharmaceutical composition according to claim 23, wherein said additional therapeutic agent is an imaging agent, a cytotoxic agent, an angiogenesis inhibitor, a kinase inhibitor, a co-stimulation molecule blocker, an adhesion molecule blocker, an anti-cytokine antibody or functional fragment thereof, methotrexate, cyclosporin, rapamycin, FK506, a detectable label or reporter, a TNF antagonist, an antirheumatic, a muscle relaxant, a narcotic, a non-steroid anti-inflammatory drug (NSAID), an analgesic, an anesthetic, a sedative, a local anesthetic, a neuromuscular blocker, an antimicrobial, an antipsoriatic, a corticosteroid, an anabolic steroid, an erythropoietin, an immunization, an immunoglobulin, an immunosuppressive, a growth hormone, a hormone replacement drug, a radiopharmaceutical, an antidepressant, an antipsychotic, a stimulant, an asthma medication, a beta agonist, an inhaled steroid, an epinephrine or analog, a cytokine, or a cytokine antagonist.

25. A method of treating a subject for a disease or a disorder by administering the binding protein of any one of claims 1-11 to the subject.

26. The method of claim 25, wherein the disorder is arthritis, osteoarthritis, juvenile chronic arthritis, septic arthritis, Lyme arthritis, psoriatic arthritis, reactive arthritis, spondyloarthropathy, systemic lupus erythematosus, Crohn's disease, ulcerative colitis, inflammatory bowel disease, insulin dependent diabetes mellitus, thyroiditis, asthma, allergic diseases, psoriasis, dermatitis scleroderma, graft versus host disease, organ transplant rejection, acute or chronic immune disease associated with organ transplantation, sarcoidosis, atherosclerosis, disseminated intravascular coagulation, Kawasaki's disease, Grave's disease, nephrotic syndrome, chronic fatigue syndrome, Wegener's granulomatosis, Henoch-Schoenlein purpura, microscopic vasculitis of the kidneys, chronic active hepatitis, uveitis, septic shock, toxic shock syndrome, sepsis syndrome, cachexia, infectious diseases, parasitic diseases, acute transverse myelitis, Huntington's chorea, Parkinson's disease, Alzheimer's disease, stroke, primary biliary cirrhosis, hemolytic anemia, malignancies, heart failure, myocardial infarction, Addison's disease, sporadic polyglandular deficiency type I and polyglandular deficiency type II, Schmidt's syndrome, adult (acute) respiratory distress syndrome, alopecia, alopecia areata, seronegative arthropathy, arthropathy, Reiter's disease, psoriatic arthropathy, ulcerative colitic arthropathy, enteropathic synovitis, chlamydia, yersinia and salmonella associated arthropathy, spondyloarthropathy, atheromatous disease/arteriosclerosis, atopic allergy, autoimmune bullous disease, pemphigus vulgaris, pemphigus foliaceus, pemphigoid, linear IgA disease, autoimmune haemolytic anaemia, Coombs positive haemolytic anaemia, acquired pernicious anaemia, juvenile pernicious anaemia, myalgic encephalitis/Royal Free Disease, chronic mucocutaneous candidiasis, giant cell arteritis, primary sclerosing hepatitis, cryptogenic autoimmune hepatitis, Acquired Immunodeficiency Syndrome, Acquired Immunodeficiency Related Diseases, Hepatitis B, Hepatitis C, common varied immunodeficiency (common variable hypogammaglobulinaemia), dilated cardiomyopathy, female infertility, ovarian failure, premature ovarian failure, fibrotic lung disease, cryptogenic fibrosing alveolitis, post-inflammatory interstitial lung disease, interstitial pneumonitis, connective tissue disease associated interstitial lung disease, mixed connective tissue disease associated lung disease, systemic sclerosis associated interstitial lung disease, rheumatoid arthritis associated interstitial lung disease, systemic lupus erythematosus associated lung disease, dermatomyositis/polymyositis associated lung disease,

Sjögren's disease associated lung disease, ankylosing spondylitis associated lung disease, vasculitic diffuse lung disease, haemosiderosis associated lung disease, drug-induced interstitial lung disease, fibrosis, radiation fibrosis, bronchiolitis obliterans, chronic eosinophilic pneumonia, lymphocytic infiltrative lung disease, postinfectious interstitial lung disease, gouty arthritis, autoimmune hepatitis, type-1 autoimmune hepatitis (classical autoimmune or lupoid hepatitis), type-2 autoimmune hepatitis (anti-LKM antibody hepatitis), autoimmune mediated hypoglycaemia, type B insulin resistance with acanthosis nigricans, hypoparathyroidism, acute immune disease associated with organ transplantation, chronic immune disease associated with organ transplantation, osteoarthritis, primary sclerosing cholangitis, psoriasis type 1, psoriasis type 2, idiopathic leucopaenia, autoimmune neutropaenia, renal disease NOS, glomerulonephritides, microscopic vasculitis of the kidneys, lyme disease, discoid lupus erythematosus, male infertility idiopathic or NOS, sperm autoimmunity, multiple sclerosis (all subtypes), sympathetic ophthalmia, pulmonary hypertension secondary to connective tissue disease, Goodpasture's syndrome, pulmonary manifestation of polyarteritis nodosa, acute rheumatic fever, rheumatoid spondylitis, Still's disease, systemic sclerosis, Sjörgren's syndrome, Takayasu's disease/arteritis, autoimmune thrombocytopaenia, idiopathic thrombocytopaenia, autoimmune thyroid disease, hyperthyroidism, goitrous autoimmune hypothyroidism (Hashimoto's disease), atrophic autoimmune hypothyroidism, primary myxoedema, phacogenic uveitis, primary vasculitis, vitiligo acute liver disease, chronic liver diseases, alcoholic cirrhosis, alcohol-induced liver injury, cholestasis, idiosyncratic liver disease, Drug-Induced hepatitis, Non-alcoholic Steatohepatitis, allergy and asthma, group B streptococci (GBS) infection, mental disorders (e.g., depression and schizophrenia), Th2 Type and Th1 Type mediated diseases, acute and chronic pain (different forms of pain), and cancers such as lung, breast, stomach, bladder, colon, pancreas, ovarian, prostate and rectal cancer and hematopoietic malignancies (leukemia and lymphoma) abetalipoproteinemia, Acrocyanosis, acute and chronic parasitic or infectious processes, acute leukemia, acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), acute or chronic bacterial infection, acute pancreatitis, acute renal failure, adenocarcinomas, aerial ectopic beats, AIDS dementia complex, alcohol-induced hepatitis, allergic conjunctivitis, allergic contact dermatitis, allergic rhinitis, allograft rejection, alpha-1- antitrypsin deficiency, amyotrophic lateral sclerosis, anemia, angina pectoris, anterior horn cell degeneration, anti cd3 therapy, antiphospholipid syndrome, anti-receptor hypersensitivity reactions, aortic and peripheral aneurysms, aortic dissection, arterial hypertension, arteriosclerosis,

arteriovenous fistula, ataxia, atrial fibrillation (sustained or paroxysmal), atrial flutter, atrioventricular block, B cell lymphoma, bone graft rejection, bone marrow transplant (BMT) rejection, bundle branch block, Burkitt's lymphoma, burns, cardiac arrhythmias, cardiac stun syndrome, cardiac tumors, cardiomyopathy, cardiopulmonary bypass inflammation response, cartilage transplant rejection, cerebellar cortical degenerations, cerebellar disorders, chaotic or multifocal atrial tachycardia, chemotherapy associated disorders, chronic myelocytic leukemia (CML), chronic alcoholism, chronic inflammatory pathologies, chronic lymphocytic leukemia (CLL), chronic obstructive pulmonary disease (COPD), chronic salicylate intoxication, colorectal carcinoma, congestive heart failure, conjunctivitis, contact dermatitis, cor pulmonale, coronary artery disease, Creutzfeldt-Jakob disease, culture negative sepsis, cystic fibrosis, cytokine therapy associated disorders, Dementia pugilistica, demyelinating diseases, dengue hemorrhagic fever, dermatitis, dermatologic conditions, diabetes, diabetes mellitus, diabetic atherosclerotic disease, Diffuse Lewy body disease, dilated congestive cardiomyopathy, disorders of the basal ganglia, Down's Syndrome in middle age, drug- induced movement disorders induced by drugs which block CNS dopamine receptors, drug sensitivity, eczema, encephalomyelitis, endocarditis, endocrinopathy, epiglottitis, epstein-barr virus infection, erythromelalgia, extrapyramidal and cerebellar disorders, familial hemophagocytic lymphohistiocytosis, fetal thymus implant rejection, Friedreich's ataxia, functional peripheral arterial disorders, fungal sepsis, gas gangrene, gastric ulcer, graft rejection of any organ or tissue, gram negative sepsis, gram positive sepsis, granulomas due to intracellular organisms, hairy cell leukemia, Hallerorden-Spatz disease, hashimoto's thyroiditis, hay fever, heart transplant rejection, hemachromatosis, hemodialysis, hemolytic uremic syndrome/thrombolytic thrombocytopenic purpura, hemorrhage, hepatitis A, His bundle arrhythmias, HIV infection/HIV neuropathy, Hodgkin's disease, hyperkinetic movement disorders, hypersensitivity reactions, hypersensitivity pneumonitis, hypertension, hypokinetic movement disorders, hypothalamic-pituitary-adrenal axis evaluation, idiopathic Addison's disease, idiopathic pulmonary fibrosis, antibody mediated cytotoxicity, Asthenia, infantile spinal muscular atrophy, inflammation of the aorta, influenza a, ionizing radiation exposure, iridocyclitis/uveitis/optic neuritis, ischemia- reperfusion injury, ischemic stroke, juvenile rheumatoid arthritis, juvenile spinal muscular atrophy, Kaposi's sarcoma, kidney transplant rejection, legionella, leishmaniasis, leprosy, lesions of the corticospinal system, lipedema, liver transplant rejection, lymphedema, malaria, malignant Lymphoma, malignant histiocytosis, malignant melanoma,

meningitis, meningococemia, metabolic/idiopathic, migraine headache, mitochondrial multi.system disorder, mixed connective tissue disease, monoclonal gammopathy, multiple myeloma, multiple systems degenerations (Mencel Dejerine- Thomas Shy- Drager and Machado-Joseph), myasthenia gravis, mycobacterium avium intracellulare, mycobacterium tuberculosis, myelodysplastic syndrome, myocardial ischemic disorders, nasopharyngeal carcinoma, neonatal chronic lung disease, nephritis, nephrosis, neurodegenerative diseases, neurogenic I muscular atrophies , neutropenic fever, non- hodgkins lymphoma, occlusion of the abdominal aorta and its branches, occlusive arterial disorders, okt3 therapy, orchitis/epididymitis, orchitis/vasectomy reversal procedures, organomegaly, osteoporosis, pancreas transplant rejection, pancreatic carcinoma, paraneoplastic syndrome/hypercalcemia of malignancy, parathyroid transplant rejection, pelvic inflammatory disease, perennial rhinitis, pericardial disease, peripheral atherosclerotic disease, peripheral vascular disorders, peritonitis, pernicious anemia, pneumocystis carinii pneumonia, pneumonia, POEMS syndrome (polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy, and skin changes syndrome), post perfusion syndrome, post pump syndrome, post-MI cardiomyopathy syndrome, preeclampsia, Progressive supranuclear Palsy, primary pulmonary hypertension, radiation therapy, Raynaud's phenomenon and disease, Raynaud's disease, Refsum's disease, regular narrow QRS tachycardia, renovascular hypertension, reperfusion injury, restrictive cardiomyopathy, sarcomas, scleroderma, senile chorea, Senile Dementia of Lewy body type, seronegative arthropathies, shock, sickle cell anemia, skin allograft rejection, skin changes syndrome, small bowel transplant rejection, solid tumors, specific arrhythmias, spinal ataxia, spinocerebellar degenerations, streptococcal myositis, structural lesions of the cerebellum, Subacute sclerosing panencephalitis, Syncope, syphilis of the cardiovascular system, systemic anaphylaxis, systemic inflammatory response syndrome, systemic onset juvenile rheumatoid arthritis, T-cell or FAB ALL, Telangiectasia, thromboangitis obliterans, thrombocytopenia, toxicity, transplants, trauma/hemorrhage, type III hypersensitivity reactions, type IV hypersensitivity, unstable angina, uremia, urosepsis, urticaria, valvular heart diseases, varicose veins, ,vasculitis, venous diseases, venous thrombosis, ventricular fibrillation, viral and fungal infections, viral encephalitis/aseptic meningitis, viral-associated hemophagocytic syndrome, Wernicke- Korsakoff syndrome, Wilson's disease, xenograft rejection of any organ or tissue, acute coronary syndromes, acute idiopathic polyneuritis, acute inflammatory demyelinating polyradiculoneuropathy, acute ischemia, adult Still's disease, anaphylaxis, anti-phospholipid antibody syndrome,

aplastic anemia, atopic eczema, atopic dermatitis, autoimmune dermatitis, autoimmune disorder associated with streptococcus infection, autoimmune enteropathy, autoimmune hearing loss, autoimmune lymphoproliferative syndrome (ALPS), autoimmune myocarditis, autoimmune premature ovarian failure, blepharitis, bronchiectasis, bullous pemphigoid, cardiovascular disease, catastrophic antiphospholipid syndrome, celiac disease, cervical spondylosis, chronic ischemia, cicatricial pemphigoid, clinically isolated syndrome (cis) with risk for multiple sclerosis, childhood onset psychiatric disorder, dacryocystitis, dermatomyositis, diabetic retinopathy, disk herniation, disk prolaps, drug induced immune hemolytic anemia, endometriosis, endophthalmitis, episcleritis, erythema multiforme, erythema multiforme major, gestational pemphigoid, Guillain-Barré syndrome (GBS), hay fever, Hughes syndrome, idiopathic Parkinson's disease, idiopathic interstitial pneumonia, IgE-mediated allergy, immune hemolytic anemia, inclusion body myositis, infectious ocular inflammatory disease, inflammatory demyelinating disease, inflammatory heart disease, inflammatory kidney disease, IPF/UIP, iritis, keratitis, keratoconjunctivitis sicca, Kussmaul disease or Kussmaul-Meier disease, Landry's paralysis, Langerhan's cell histiocytosis, livedo reticularis, macular degeneration, microscopic polyangiitis, morbus bechterev, motor neuron disorders, mucous membrane pemphigoid, multiple organ failure, myelodysplastic syndrome, myocarditis, nerve root disorders, neuropathy, non-A non-B hepatitis, optic neuritis, osteolysis, ovarian cancer, pauciarticular JRA, peripheral artery occlusive disease (PAOD), peripheral vascular disease (PVD), peripheral artery, disease (PAD), phlebitis, polyarteritis nodosa (or periarteritis nodosa), polychondritis, polymyalgia rheumatica, poliosis, polyarticular JRA, polyendocrine deficiency syndrome, polymyositis, post-pump syndrome, primary Parkinsonism, prostate and rectal cancer and hematopoietic malignancies (leukemia and lymphoma), prostatitis, pure red cell aplasia, primary adrenal insufficiency, recurrent neuromyelitis optica, restenosis, rheumatic heart disease, sapho (synovitis, acne, pustulosis, hyperostosis, and osteitis), scleroderma, secondary amyloidosis, shock lung, scleritis, sciatica, secondary adrenal insufficiency, silicone associated connective tissue disease, sneddon-wilkinson dermatosis, spondilitis ankylosans, Stevens-Johnson syndrome (SJS), systemic inflammatory response syndrome, temporal arteritis, toxoplasmic retinitis, toxic epidermal necrolysis, transverse myelitis, TRAPS (tumor necrosis factor receptor, type 1 allergic reaction, type II diabetes, usual interstitial pneumonia (UIP), vernal conjunctivitis, viral retinitis, Vogt-Koyanagi-Harada syndrome (VKH syndrome), wet macular degeneration, or wound healing.

27. The method of claim 25 or 26, wherein the binding protein is formulated for parenteral, subcutaneous, intramuscular, intravenous, intrarticular, intrabronchial, intraabdominal, intracapsular, intracartilaginous, intracavitary, intracelial, intracerebellar, intracerebroventricular, intracolic, intracervical, intragastric, intrahepatic, intramyocardial, intraosteal, intrapelvic, intrapericardiac, intraperitoneal, intrapleural, intraprostatic, intrapulmonary, intrarectal, intrarenal, intraretinal, intraspinal, intrasynovial, intrathoracic, intrauterine, intravesical, bolus, vaginal, rectal, buccal, sublingual, intranasal, or transdermal administration.

28. A method of determining the presence, amount, or concentration of at least one target or fragment thereof in a test sample by an immunoassay,

wherein the immunoassay comprises contacting the test sample with at least one binding protein and at least one detectable label, and

wherein the at least one binding protein comprises the binding protein of any one of claims 1-11.

29. The method of claim 28, further comprising:

(i) contacting the test sample with the at least one binding protein, wherein the binding protein binds to an epitope on the target or fragment thereof so as to form a first complex;

(ii) contacting the complex with the at least one detectable label, wherein the detectable label binds to the binding protein or an epitope on the target or fragment thereof that is not bound by the binding protein to form a second complex; and

(iii) detecting the presence, amount, or concentration of the target or fragment thereof in the test sample based on the signal generated by the detectable label in the second complex, wherein the presence, amount, or concentration of the target or fragment thereof is directly correlated with the signal generated by the detectable label.

30. The method of claim 28, further comprising:

(i) contacting the test sample with the at least one binding protein, wherein the binding protein binds to an epitope on the target or fragment thereof so as to form a first complex;

(ii) contacting the complex with the at least one detectable label, wherein the detectable label competes with the target or fragment thereof for binding to the binding protein so as to form a second complex; and

(iii) detecting the presence, amount, or concentration of the target or fragment thereof in the test sample based on the signal generated by the detectable label in the second complex, wherein the presence, amount, or concentration of the target or fragment thereof is indirectly correlated with the signal generated by the detectable label.

31. The method according to claim 28, wherein the test sample is from a patient and the method further comprises diagnosing, prognosticating, or assessing the efficiency of therapeutic/prophylactic treatment of the patient, and

wherein if the method further comprises assessing the efficacy of therapeutic/prophylactic treatment of the patient, the method also further comprises modifying the therapeutic/prophylactic treatment of the patient as needed to improve efficacy.

32. The method according to claim 28, wherein the method is adapted for use in an automated system or a semi-automated system.

33. The method according to claim 28, wherein the test sample is from a patient and the method determines the presence, amount, or concentration of more than one target in the sample.

34. A kit for assaying a test sample for the presence, amount, or concentration of a target or fragment thereof in the sample, said kit comprising (a) instructions for assaying the test sample for the target or fragment thereof and (b) at least one binding protein comprising the binding protein of any one of claims 1-11.

35. A binding protein comprising first and second polypeptide chains, each independently comprising VD1-(X1)_n-VD2-C-X2, wherein

VD1 is a first variable domain;

VD2 is a second variable domain;

C is a constant domain;

X1 is a linker;

X2 is an Fc region that is either present or absent; and

n is 0 or 1;

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein the binding protein is capable of binding IL-1 β and IL-17, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise a sequence selected from the group consisting of SEQ ID NOs: 32-41;

and

(ii) the variable domains that form a functional target binding site for IL-17 comprise a sequence selected from the group consisting of SEQ ID NO: 42-47.

36. A binding protein comprising first and second polypeptide chains, each independently comprising VD1-(X1) n -VD2-C-X2, wherein

VD1 is a first variable domain;

VD2 is a second variable domain;

C is a constant domain;

X1 is a linker;

X2 is an Fc region that is either present or absent;

n is 0 or 1,

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site, and wherein the binding protein is capable of binding IL-1 β and IL-17, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise:

CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33,
 CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35,
 CDRs 1-3 from SEQ ID NO: 36 and CDRs 1-3 from SEQ ID NO: 37,
 CDRs 1-3 from SEQ ID NO: 38 and CDRs 1-3 from SEQ ID NO: 39, or
 CDRs 1-3 from SEQ ID NO: 40 and CDRs 1-3 from SEQ ID NO: 41;

and/or

(ii) the variable domains that form a functional target binding site for IL-17 comprise

CDRs 1-3 from SEQ ID NO: 42 and CDRs 1-3 from SEQ ID NO: 43,
 CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45,
 or
 CDRs 1-3 from SEQ ID NO: 46 and CDRs 1-3 from SEQ ID NO: 47.

37. The binding protein of claim 35 or 36, wherein the first polypeptide chain comprises VD1-(X1) n -VD2-C-X2, wherein

VD1 is a first heavy chain variable domain;
 VD2 is a second heavy chain variable domain;
 C is a heavy chain constant domain;
 X1 is a linker;
 X2 is an Fc region that is either present or absent;
 n is 0 or 1, and

wherein the second polypeptide chain comprises VD1-(X1) n -VD2-C, wherein

VD1 is a first light chain variable domain;
 VD2 is a second light chain variable domain;

C is a light chain constant domain;

X1 is a linker;

n is 0 or 1,

wherein the VD1 domains on the first and second polypeptide chains form a first functional target binding site and the VD2 domains on the first and second polypeptide chains form a second functional target binding site.

38. The binding protein of any one of claims 35-37, wherein

(i) the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 2.563 nM, as measured in an IL-1 β neutralization assay, and/or

(ii) the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 1.7 nM, as measured in an IL-17 neutralization assay.

39. The binding protein of any one of claims 35-38, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise:

(1) SEQ ID NO: 32 and SEQ ID NO: 33,

(2) SEQ ID NO: 34 and SEQ ID NO: 35,

(3) SEQ ID NO: 36 and SEQ ID NO: 37,

(4) SEQ ID NO: 38 and SEQ ID NO: 39, or

(5) SEQ ID NO: 40 and SEQ ID NO: 41;

and

(ii) the variable domains that form a functional target binding site for IL-17 comprise:

(1) SEQ ID NO: 42 and SEQ ID NO: 43,

(2) SEQ ID NO: 44 and SEQ ID NO: 45, or

(3) SEQ ID NO: 46 and SEQ ID NO: 47.

40. The binding protein of any one of claims 35-39, comprising two first polypeptide chains and two second polypeptide chains and four functional target binding sites.

41. The binding protein of any one of claims 35-40, wherein X1 is any one of SEQ ID NO: 1-31.

42. The binding protein of any one of claims 35-41, wherein X1 is not CH1 or CL.

43. The binding protein of any one of claims 35-42, wherein the Fc region is a variant sequence Fc region, and/or wherein the Fc region is an Fc region from an IgG1, IgG2, IgG3, IgG4, IgA, IgM, IgE, or IgD.

44. The binding protein of any one of claims 35-43, wherein the binding protein comprises

(a) a heavy chain constant region comprising:

(i) a wild type human IgG1 heavy chain sequence, or

(ii) a human IgG1 heavy chain sequence modified by one or more amino acid changes, optionally wherein the changes comprise substitutions at amino acid positions 234 and 235 of the constant region sequence, optionally wherein the changes comprise the substitution of leucines at positions 234 and 235 with alanines;

and/or

(b) a light chain constant region comprising:

(i) a wild type human kappa light chain constant region sequence, or

(ii) a wild type human lamda light chain constant region sequence.

45. The binding protein of any one of claims 35-10, wherein the binding protein is a crystallized binding protein.

46. The binding protein of any one of claims 35-45, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise CDRs 1-3 from SEQ ID NO: 32 and CDRs 1-3 from SEQ ID NO: 33,

and

(ii) the variable domains that form a functional target binding site for IL-17 comprise CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45.

47. The binding protein of claim 46, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise SEQ ID NO: 32 and SEQ ID NO: 33,

and

(ii) the variable domains that form a functional target binding site for IL-17 comprise SEQ ID NO: 44 and SEQ ID NO: 45.

48. The binding protein according to claim 46 or 47, wherein X1 on one polypeptide chain comprises SEQ ID NO: 29 and X1 on the other polypeptide chain comprises SEQ ID NO: 30.

49. The binding protein of any one of claims 46-48, wherein the binding protein comprises DVD3415 (containing first and second polypeptide chains comprising SEQ ID NOs: 98 and 99).

50. The binding protein of any one of claims 46-49, wherein:

(i) the binding protein is capable of binding IL-1 β with a K_D of at most about 5.1×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 0.027 nM, as measured in an IL-1 β neutralization assay, and/or

(ii) the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 0.091 nM, as measured in an IL-17 neutralization assay.

51. The binding protein of any one of claims 35-45, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise CDRs 1-3 from SEQ ID NO: 34 and CDRs 1-3 from SEQ ID NO: 35, and

(ii) the variable domains that form a functional target binding site for IL-17 comprise CDRs 1-3 from SEQ ID NO: 44 and CDRs 1-3 from SEQ ID NO: 45.

52. The binding protein of claim 51, wherein

(i) the variable domains that form a functional target binding site for IL-1 β comprise SEQ ID NO: 34 and SEQ ID NO: 35, and

(ii) the variable domains that form a functional target binding site for IL-17 comprise SEQ ID NO: 44 and SEQ ID NO: 45.

53. The binding protein according to claim 51 or 52, wherein X1 on one polypeptide chain comprises SEQ ID NO: 29 and X1 on the other polypeptide chain comprises SEQ ID NO: 30.

54. The binding protein of any one of claims 51-53, wherein the binding protein comprises DVD3418 (containing first and second polypeptide chains comprising SEQ ID NOs: 104 and 105)

55. The binding protein of any one of claims 51-54, wherein:

(i) the binding protein is capable of binding IL-1 β with a K_D of at most about 3.4×10^{-11} M, as measured by surface plasmon resonance, or capable of inhibiting IL-1 β with an IC50 of at most about 0.018 nM, as measured in an IL-1 β neutralization assay, and/or

(ii) the binding protein is capable of binding IL-17 with a K_D of at most about 4.8×10^{-12} M, as measured by surface plasmon resonance, or capable of inhibiting IL-17 with an IC50 of at most about 0.068 nM, as measured in an IL-17 neutralization assay.

56. A binding protein capable of binding IL-1 β and IL-17, wherein the binding protein comprises any one of:

DVD2423 (comprising SEQ ID NOs: 48 and 49);

DVD2424 (comprising SEQ ID NOs: 50 and 51);
DVD2425 (comprising SEQ ID NOs: 52 and 53);
DVD2426 (comprising SEQ ID NOs: 54 and 55);
DVD2427 (comprising SEQ ID NOs: 56 and 57);
DVD2428 (comprising SEQ ID NOs: 58 and 59);
DVD2429 (comprising SEQ ID NOs: 60 and 61);
DVD2430 (comprising SEQ ID NOs: 62 and 63);
DVD2431 (comprising SEQ ID NOs: 64 and 65);
DVD2432 (comprising SEQ ID NOs: 66 and 67);
DVD2433 (comprising SEQ ID NOs: 68 and 69);
DVD2434 (comprising SEQ ID NOs: 70 and 71);
DVD2435 (comprising SEQ ID NOs: 72 and 73);
DVD2436 (comprising SEQ ID NOs: 74 and 75);
DVD2437 (comprising SEQ ID NOs: 76 and 77);
DVD2438 (comprising SEQ ID NOs: 78 and 79);
DVD2439 (comprising SEQ ID NOs: 80 and 81);
DVD2440 (comprising SEQ ID NOs: 82 and 83);
DVD2441 (comprising SEQ ID NOs: 84 and 85);
DVD2442 (comprising SEQ ID NOs: 86 and 87);
DVD3410 (comprising SEQ ID NOs: 88 and 89);
DVD3411 (comprising SEQ ID NOs: 90 and 91);
DVD3412 (comprising SEQ ID NOs: 92 and 93);
DVD3413 (comprising SEQ ID NOs: 94 and 95);
DVD3414 (comprising SEQ ID NOs: 96 and 97);
DVD3415 (comprising SEQ ID NOs: 98 and 99);
DVD3416 (comprising SEQ ID NOs: 100 and 101);
DVD3417 (comprising SEQ ID NOs: 102 and 103);
DVD3418 (comprising SEQ ID NOs: 104 and 105);
DVD3419 (comprising SEQ ID NOs: 106 and 107);
DVD3420 (comprising SEQ ID NOs: 108 and 109);
DVD3421 (comprising SEQ ID NOs: 110 and 111);
DVD3422 (comprising SEQ ID NOs: 112 and 113);
DVD3423 (comprising SEQ ID NOs: 114 and 115);
DVD3424 (comprising SEQ ID NOs: 116 and 117); and
DVD3425 (comprising SEQ ID NOs: 118 and 119).

57. A binding protein conjugate comprising the binding protein according to any one of claims 35-56, said binding protein conjugate further comprising an immunoadhesion molecule, an imaging agent, a therapeutic agent, or a cytotoxic agent.
58. The binding protein conjugate of claim 57, wherein the imaging agent is a radiolabel, an enzyme, a fluorescent label, a luminescent label, a bioluminescent label, a magnetic label, or biotin.
59. The binding protein conjugate of claim 58, wherein the radiolabel is ^3H , ^{14}C , ^{35}S , ^{90}Y , ^{99}Tc , ^{111}In , ^{125}I , ^{131}I , ^{177}Lu , ^{166}Ho , or ^{153}Sm .
60. The binding protein conjugate of claim 57, wherein the therapeutic or cytotoxic agent is an anti-metabolite, an alkylating agent, an antibiotic, a growth factor, a cytokine, an anti-angiogenic agent, an anti-mitotic agent, an anthracycline, toxin, or an apoptotic agent.
61. An isolated nucleic acid encoding the binding protein amino acid sequence according to any one of claims 35-56.
62. A vector comprising the isolated nucleic acid according to claim 61.
63. The vector of claim 62, wherein the vector comprises pcDNA, pTT, pTT3, pEFBOS, pBV, pJV, pcDNA3.1 TOPO, pEF6, pHybE, TOPO, or pBJ.
64. A host cell comprising the vector of claim 62 or 63.
65. The host cell of claim 64, wherein the host cell is a prokaryotic cell, *Escherichia coli*, a eukaryotic cell, a protist cell, an animal cell, a plant cell, a fungal cell, a yeast cell, an Sf9 cell, a mammalian cell, an avian cell, an insect cell, a CHO cell or a COS cell.
66. A method of producing a binding protein, comprising culturing the host cell of claim 64 or 65 in culture medium under conditions sufficient to produce the binding protein.
67. A pharmaceutical composition comprising the binding protein according to any one of claims 35-56, and a pharmaceutically acceptable carrier.

68. The pharmaceutical composition of claim 67, further comprising at least one additional therapeutic agent.

69. The pharmaceutical composition according to claim 68, wherein the additional therapeutic agent is an imaging agent, a cytotoxic agent, an angiogenesis inhibitor, a kinase inhibitor, a co-stimulation molecule blocker, an adhesion molecule blocker, an anti-cytokine antibody or functional fragment thereof, methotrexate, cyclosporin, rapamycin, FK506, a detectable label or reporter, a TNF antagonist, an antirheumatic, a muscle relaxant, a narcotic, a non-steroid anti-inflammatory drug (NSAID), an analgesic, an anesthetic, a sedative, a local anesthetic, a neuromuscular blocker, an antimicrobial, an antipsoriatic, a corticosteroid, an anabolic steroid, an erythropoietin, an immunization, an immunoglobulin, an immunosuppressive, a growth hormone, a hormone replacement drug, a radiopharmaceutical, an antidepressant, an antipsychotic, a stimulant, an asthma medication, a beta agonist, an inhaled steroid, an epinephrine or analog, a cytokine, or a cytokine antagonist.

70. A method of treating a subject for a disease or a disorder by administering the binding protein of any one of claims 35-56 to the subject.

71. The method of claim 70, wherein the disorder is arthritis, osteoarthritis, juvenile chronic arthritis, septic arthritis, Lyme arthritis, psoriatic arthritis, reactive arthritis, spondyloarthropathy, systemic lupus erythematosus, Crohn's disease, ulcerative colitis, inflammatory bowel disease, insulin dependent diabetes mellitus, thyroiditis, asthma, allergic diseases, psoriasis, dermatitis scleroderma, graft versus host disease, organ transplant rejection, acute or chronic immune disease associated with organ transplantation, sarcoidosis, atherosclerosis, disseminated intravascular coagulation, Kawasaki's disease, Grave's disease, nephrotic syndrome, chronic fatigue syndrome, Wegener's granulomatosis, Henoch-Schoenlein purpura, microscopic vasculitis of the kidneys, chronic active hepatitis, uveitis, septic shock, toxic shock syndrome, sepsis syndrome, cachexia, infectious diseases, parasitic diseases, acute transverse myelitis, Huntington's chorea, Parkinson's disease, Alzheimer's disease, stroke, primary biliary cirrhosis, hemolytic anemia, malignancies, heart failure, myocardial infarction, Addison's disease, sporadic polyglandular deficiency type I and polyglandular deficiency type II, Schmidt's syndrome, adult (acute) respiratory distress syndrome, alopecia, alopecia areata, seronegative arthropathy, arthropathy, Reiter's disease, psoriatic arthropathy, ulcerative colitic arthropathy, enteropathic synovitis, chlamydia, yersinia and salmonella associated

arthropathy, spondyloarthropathy, atheromatous disease/arteriosclerosis, atopic allergy, autoimmune bullous disease, pemphigus vulgaris, pemphigus foliaceus, pemphigoid, linear IgA disease, autoimmune haemolytic anaemia, Coombs positive haemolytic anaemia, acquired pernicious anaemia, juvenile pernicious anaemia, myalgic encephalitis/Royal Free Disease, chronic mucocutaneous candidiasis, giant cell arteritis, primary sclerosing hepatitis, cryptogenic autoimmune hepatitis, Acquired Immunodeficiency Syndrome, Acquired Immunodeficiency Related Diseases, Hepatitis B, Hepatitis C, common varied immunodeficiency (common variable hypogammaglobulinaemia), dilated cardiomyopathy, female infertility, ovarian failure, premature ovarian failure, fibrotic lung disease, cryptogenic fibrosing alveolitis, post-inflammatory interstitial lung disease, interstitial pneumonitis, connective tissue disease associated interstitial lung disease, mixed connective tissue disease associated lung disease, systemic sclerosis associated interstitial lung disease, rheumatoid arthritis associated interstitial lung disease, systemic lupus erythematosus associated lung disease, dermatomyositis/polymyositis associated lung disease, Sjögren's disease associated lung disease, ankylosing spondylitis associated lung disease, vasculitic diffuse lung disease, haemosiderosis associated lung disease, drug-induced interstitial lung disease, fibrosis, radiation fibrosis, bronchiolitis obliterans, chronic eosinophilic pneumonia, lymphocytic infiltrative lung disease, postinfectious interstitial lung disease, gouty arthritis, autoimmune hepatitis, type-1 autoimmune hepatitis (classical autoimmune or lupoid hepatitis), type-2 autoimmune hepatitis (anti-LKM antibody hepatitis), autoimmune mediated hypoglycaemia, type B insulin resistance with acanthosis nigricans, hypoparathyroidism, acute immune disease associated with organ transplantation, chronic immune disease associated with organ transplantation, osteoarthritis, primary sclerosing cholangitis, psoriasis type 1, psoriasis type 2, idiopathic leucopaenia, autoimmune neutropaenia, renal disease NOS, glomerulonephritides, microscopic vasculitis of the kidneys, lyme disease, discoid lupus erythematosus, male infertility idiopathic or NOS, sperm autoimmunity, multiple sclerosis (all subtypes), sympathetic ophthalmia, pulmonary hypertension secondary to connective tissue disease, Goodpasture's syndrome, pulmonary manifestation of polyarteritis nodosa, acute rheumatic fever, rheumatoid spondylitis, Still's disease, systemic sclerosis, Sjörgren's syndrome, Takayasu's disease/arteritis, autoimmune thrombocytopaenia, idiopathic thrombocytopaenia, autoimmune thyroid disease, hyperthyroidism, goitrous autoimmune hypothyroidism (Hashimoto's disease), atrophic autoimmune hypothyroidism, primary myxoedema, phacogenic uveitis, primary vasculitis, vitiligo acute liver disease, chronic liver

diseases, alcoholic cirrhosis, alcohol-induced liver injury, cholestasis, idiosyncratic liver disease, Drug-Induced hepatitis, Non-alcoholic Steatohepatitis, allergy and asthma, group B streptococci (GBS) infection, mental disorders (e.g., depression and schizophrenia), Th2 Type and Th1 Type mediated diseases, acute and chronic pain (different forms of pain), and cancers such as lung, breast, stomach, bladder, colon, pancreas, ovarian, prostate and rectal cancer and hematopoietic malignancies (leukemia and lymphoma) abetalipoproteinemia, Acrocyanosis, acute and chronic parasitic or infectious processes, acute leukemia, acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), acute or chronic bacterial infection, acute pancreatitis, acute renal failure, adenocarcinomas, aural ectopic beats, AIDS dementia complex, alcohol-induced hepatitis, allergic conjunctivitis, allergic contact dermatitis, allergic rhinitis, allograft rejection, alpha-1- antitrypsin deficiency, amyotrophic lateral sclerosis, anemia, angina pectoris, anterior horn cell degeneration, anti cd3 therapy, antiphospholipid syndrome, anti-receptor hypersensitivity reactions, aortic and peripheral aneurysms, aortic dissection, arterial hypertension, arteriosclerosis, arteriovenous fistula, ataxia, atrial fibrillation (sustained or paroxysmal), atrial flutter, atrioventricular block, B cell lymphoma, bone graft rejection, bone marrow transplant (BMT) rejection, bundle branch block, Burkitt's lymphoma, burns, cardiac arrhythmias, cardiac stun syndrome, cardiac tumors, cardiomyopathy, cardiopulmonary bypass inflammation response, cartilage transplant rejection, cerebellar cortical degenerations, cerebellar disorders, chaotic or multifocal atrial tachycardia, chemotherapy associated disorders, chronic myelocytic leukemia (CML), chronic alcoholism, chronic inflammatory pathologies, chronic lymphocytic leukemia (CLL), chronic obstructive pulmonary disease (COPD), chronic salicylate intoxication, colorectal carcinoma, congestive heart failure, conjunctivitis, contact dermatitis, cor pulmonale, coronary artery disease, Creutzfeldt-Jakob disease, culture negative sepsis, cystic fibrosis, cytokine therapy associated disorders, Dementia pugilistica, demyelinating diseases, dengue hemorrhagic fever, dermatitis, dermatologic conditions, diabetes, diabetes mellitus, diabetic atherosclerotic disease, Diffuse Lewy body disease, dilated congestive cardiomyopathy, disorders of the basal ganglia, Down's Syndrome in middle age, drug- induced movement disorders induced by drugs which block CNS dopamine receptors, drug sensitivity, eczema, encephalomyelitis, endocarditis, endocrinopathy, epiglottitis, epstein-barr virus infection, erythromelalgia, extrapyramidal and cerebellar disorders, familial hemophagocytic lymphohistiocytosis, fetal thymus implant rejection, Friedreich's ataxia, functional peripheral arterial disorders, fungal sepsis, gas gangrene, gastric

ulcer, graft rejection of any organ or tissue, gram negative sepsis, gram positive sepsis, granulomas due to intracellular organisms, hairy cell leukemia, Hallerorden-Spatz disease, hashimoto's thyroiditis, hay fever, heart transplant rejection, hemachromatosis, hemodialysis, hemolytic uremic syndrome/thrombolytic thrombocytopenic purpura, hemorrhage, hepatitis A, His bundle arrhythmias, HIV infection/HIV neuropathy, Hodgkin's disease, hyperkinetic movement disorders, hypersensitivity reactions, hypersensitivity pneumonitis, hypertension, hypokinetic movement disorders, hypothalamic-pituitary-adrenal axis evaluation, idiopathic Addison's disease, idiopathic pulmonary fibrosis, antibody mediated cytotoxicity, Asthenia, infantile spinal muscular atrophy, inflammation of the aorta, influenza a, ionizing radiation exposure, iridocyclitis/uveitis/optic neuritis, ischemia- reperfusion injury, ischemic stroke, juvenile rheumatoid arthritis, juvenile spinal muscular atrophy, Kaposi's sarcoma, kidney transplant rejection, legionella, leishmaniasis, leprosy, lesions of the corticospinal system, lipedema, liver transplant rejection, lymphedema, malaria, malignant Lymphoma, malignant histiocytosis, malignant melanoma, meningitis, meningococcemia, metabolic/idiopathic, migraine headache, mitochondrial multi.system disorder, mixed connective tissue disease, monoclonal gammopathy, multiple myeloma, multiple systems degenerations (Mencel Dejerine- Thomas Shy- Drager and Machado-Joseph), myasthenia gravis, mycobacterium avium intracellulare, mycobacterium tuberculosis, myelodysplastic syndrome, myocardial ischemic disorders, nasopharyngeal carcinoma, neonatal chronic lung disease, nephritis, nephrosis, neurodegenerative diseases, neurogenic I muscular atrophies , neutropenic fever, non- hodgkins lymphoma, occlusion of the abdominal aorta and its branches, occlusive arterial disorders, okt3 therapy, orchitis/epididymitis, orchitis/vasectomy reversal procedures, organomegaly, osteoporosis, pancreas transplant rejection, pancreatic carcinoma, paraneoplastic syndrome/hypercalcemia of malignancy, parathyroid transplant rejection, pelvic inflammatory disease, perennial rhinitis, pericardial disease, peripheral atherosclerotic disease, peripheral vascular disorders, peritonitis, pernicious anemia, pneumocystis carinii pneumonia, pneumonia, POEMS syndrome (polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy, and skin changes syndrome), post perfusion syndrome, post pump syndrome, post-MI cardiomyopathy syndrome, preeclampsia, Progressive supranuclear Palsy, primary pulmonary hypertension, radiation therapy, Raynaud's phenomenon and disease, Raynaud's disease, Refsum's disease, regular narrow QRS tachycardia, renovascular hypertension, reperfusion injury, restrictive cardiomyopathy, sarcomas, scleroderma, senile chorea, Senile Dementia of Lewy body type, seronegative

arthropathies, shock, sickle cell anemia, skin allograft rejection, skin changes syndrome, small bowel transplant rejection, solid tumors, specific arrhythmias, spinal ataxia, spinocerebellar degenerations, streptococcal myositis, structural lesions of the cerebellum, Subacute sclerosing panencephalitis, Syncope, syphilis of the cardiovascular system, systemic anaphalaxis, systemic inflammatory response syndrome, systemic onset juvenile rheumatoid arthritis, T-cell or FAB ALL, Telangiectasia, thromboangitis obliterans, thrombocytopenia, toxicity, transplants, trauma/hemorrhage, type III hypersensitivity reactions, type IV hypersensitivity, unstable angina, uremia, urosepsis, urticaria, valvular heart diseases, varicose veins, ,vasculitis, venous diseases, venous thrombosis, ventricular fibrillation, viral and fungal infections, viral encephalitis/aseptic meningitis, viral-associated hemaphagocytic syndrome, Wernicke- Korsakoff syndrome, Wilson's disease, xenograft rejection of any organ or tissue, acute coronary syndromes, acute idiopathic polyneuritis, acute inflammatory demyelinating polyradiculoneuropathy, acute ischemia, adult Still's disease, anaphylaxis, anti-phospholipid antibody syndrome, aplastic anemia, atopic eczema, atopic dermatitis, autoimmune dermatitis, autoimmune disorder associated with streptococcus infection, autoimmune enteropathy, autoimmune hearing loss, autoimmune lymphoproliferative syndrome (ALPS), autoimmune myocarditis, autoimmune premature ovarian failure, blepharitis, bronchiectasis, bullous pemphigoid, cardiovascular disease, catastrophic antiphospholipid syndrome, celiac disease, cervical spondylosis, chronic ischemia, cicatricial pemphigoid, clinically isolated syndrome (cis) with risk for multiple sclerosis, childhood onset psychiatric disorder, dacryocystitis, dermatomyositis, diabetic retinopathy, disk herniation, disk prolaps, drug induced immune hemolytic anemia, endometriosis, endophthalmitis, episcleritis, erythema multiforme, erythema multiforme major, gestational pemphigoid, Guillain-Barré syndrome (GBS), hay fever, Hughes syndrome, idiopathic Parkinson's disease, idiopathic interstitial pneumonia, IgE-mediated allergy, immune hemolytic anemia, inclusion body myositis, infectious ocular inflammatory disease, inflammatory demyelinating disease, inflammatory heart disease, inflammatory kidney disease, IPF/UIP, iritis, keratitis, keratoconjunctivitis sicca, Kussmaul disease or Kussmaul-Meier disease, Landry's paralysis, Langerhan's cell histiocytosis, livedo reticularis, macular degeneration, microscopic polyangiitis, morbus bechterev, motor neuron disorders, mucous membrane pemphigoid, multiple organ failure, myelodysplastic syndrome, myocarditis, nerve root disorders, neuropathy, non-A non-B hepatitis, optic neuritis, osteolysis, ovarian cancer, pauciarticular JRA, peripheral artery occlusive disease (PAOD), peripheral vascular

disease (PVD), peripheral artery, disease (PAD), phlebitis, polyarteritis nodosa (or periarteritis nodosa), polychondritis, polymyalgia rheumatica, poliosis, polyarticular JRA, polyendocrine deficiency syndrome, polymyositis, post-pump syndrome, primary Parkinsonism, prostate and rectal cancer and hematopoietic malignancies (leukemia and lymphoma), prostatitis, pure red cell aplasia, primary adrenal insufficiency, recurrent neuromyelitis optica, restenosis, rheumatic heart disease, sapho (synovitis, acne, pustulosis, hyperostosis, and osteitis), scleroderma, secondary amyloidosis, shock lung, scleritis, sciatica, secondary adrenal insufficiency, silicone associated connective tissue disease, sneddon-wilkinson dermatosis, spondilitis ankylosans, Stevens-Johnson syndrome (SJS), systemic inflammatory response syndrome, temporal arteritis, toxoplasmic retinitis, toxic epidermal necrolysis, transverse myelitis, TRAPS (tumor necrosis factor receptor, type 1 allergic reaction, type II diabetes, usual interstitial pneumonia (UIP), vernal conjunctivitis, viral retinitis, Vogt-Koyanagi-Harada syndrome (VKH syndrome), wet macular degeneration, or wound healing.

72. The method of claim 70 or 71, wherein the disorder is an autoimmune disorder, asthma, rheumatoid arthritis, osteoarthritis, systemic lupus erythematosus (SLE), multiple sclerosis, sepsis, a neurodegenerative disease, or an oncological disorder.

73. The method of any one of claims 70-72, wherein the binding protein is formulated for parenteral, subcutaneous, intramuscular, intravenous, intrarticular, intrabronchial, intraabdominal, intracapsular, intracartilaginous, intracavitary, intracellic, intracerebellar, intracerebroventricular, intracolic, intracervical, intragastric, intrahepatic, intramyocardial, intraosteal, intrapelvic, intrapericardiac, intraperitoneal, intrapleural, intraprostatic, intrapulmonary, intrarectal, intrarenal, intraretinal, intraspinal, intrasynovial, intrathoracic, intrauterine, intravesical, bolus, vaginal, rectal, buccal, sublingual, intranasal, or transdermal administration.

74. A method of detecting the presence, amount, or concentration of at least one target or fragment thereof in a test sample by an immunoassay,

wherein the immunoassay comprises contacting the test sample with at least one binding protein and at least one detectable label, and

wherein the at least one binding protein comprises the binding protein of any one of claims 35-56.

75. The method of claim 74, further comprising:

(i) contacting the test sample with the at least one binding protein, wherein the binding protein binds to an epitope on the target or fragment thereof so as to form a first complex;

(ii) contacting the complex with the at least one detectable label, wherein the detectable label binds to the binding protein or an epitope on the target or fragment thereof that is not bound by the binding protein to form a second complex; and

(iii) detecting the presence, amount, or concentration of the target or fragment thereof in the test sample based on the signal generated by the detectable label in the second complex, wherein the presence, amount, or concentration of the target or fragment thereof is directly correlated with the signal generated by the detectable label.

76. The method of claim 74, further comprising:

(i) contacting the test sample with the at least one binding protein, wherein the binding protein binds to an epitope on the target or fragment thereof so as to form a first complex;

(ii) contacting the complex with the at least one detectable label, wherein the detectable label competes with the target or fragment thereof for binding to the binding protein so as to form a second complex; and

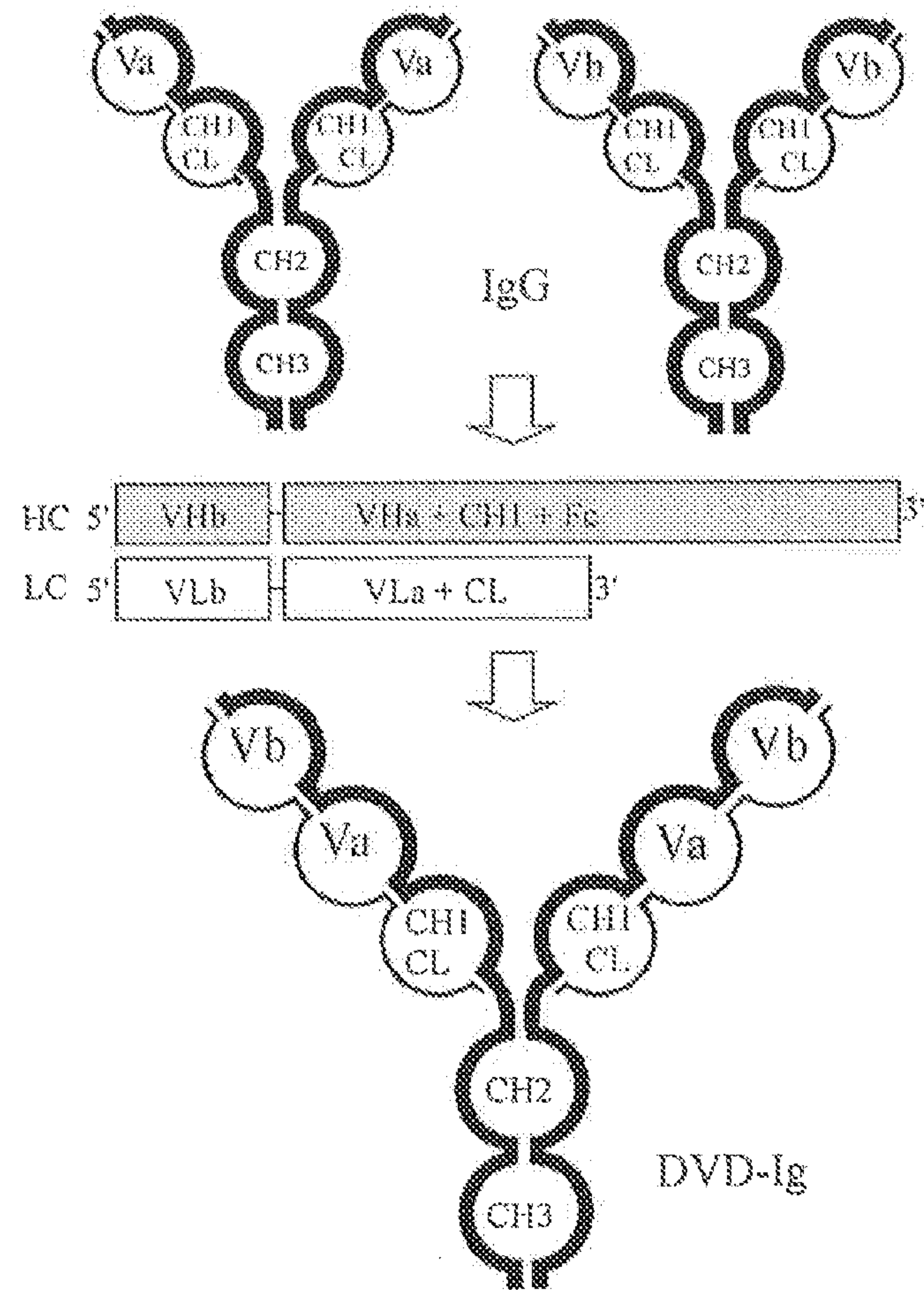
(iii) detecting the presence, amount, or concentration of the target or fragment thereof in the test sample based on the signal generated by the detectable label in the second complex, wherein the presence, amount, or concentration of the target or fragment thereof is indirectly correlated with the signal generated by the detectable label.

77. A kit for assaying a test sample for the presence, amount, or concentration of a target or fragment thereof in the sample, the kit comprising (a) instructions for assaying the test sample for the target or fragment thereof and (b) at least one binding protein comprising the binding protein of any one of claims 35-56.

78. Use of the binding protein of any one of claims 35-60 in the manufacture of a medicament for treating a disease or disorder.

Figure 1

A



B

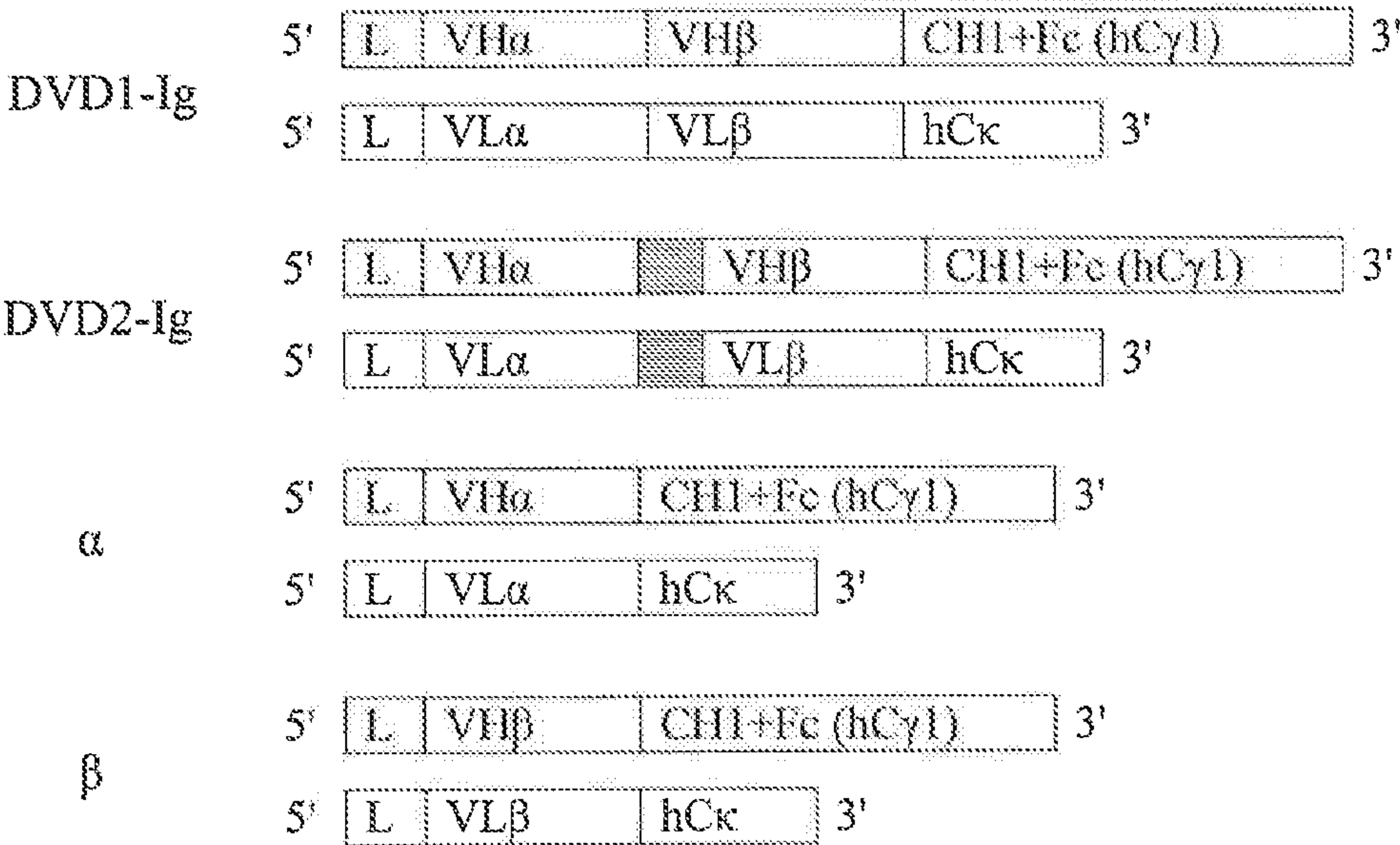
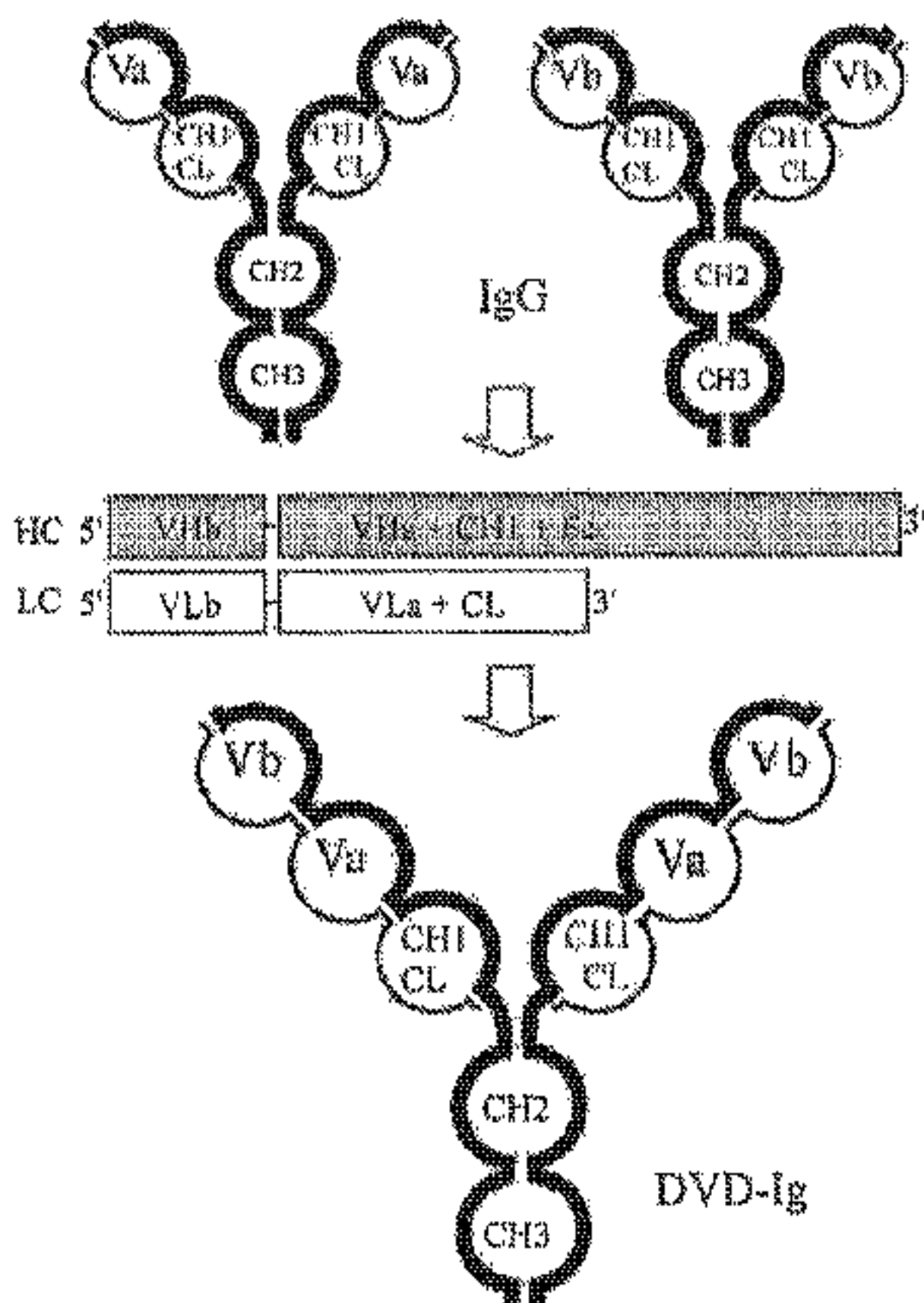


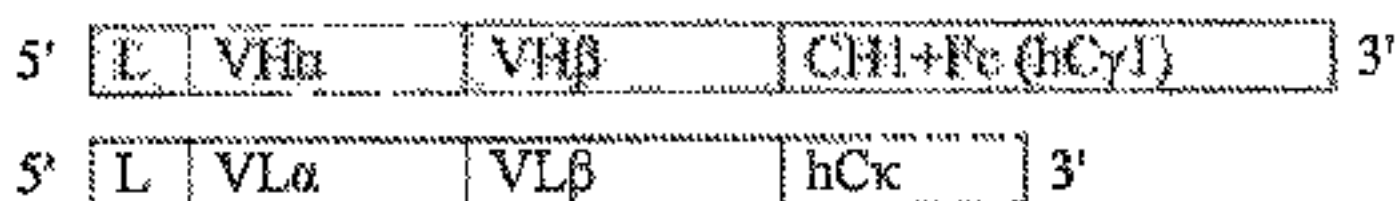
Figure 1

A

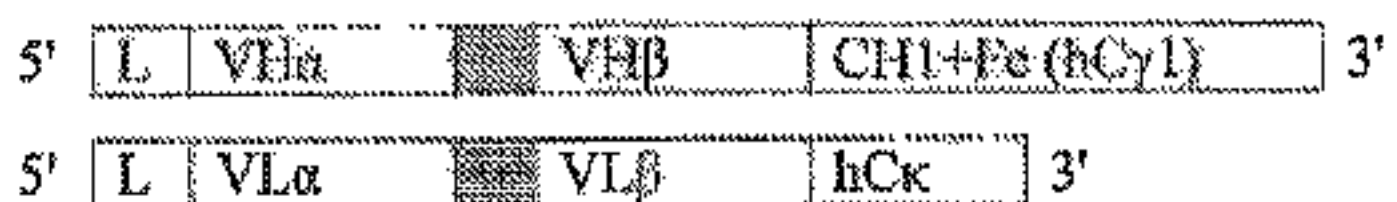


B

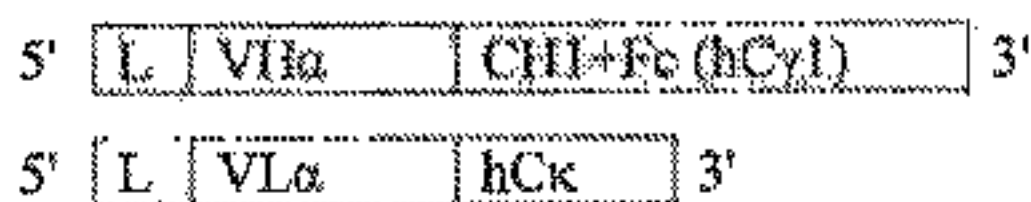
DVD1-Ig



DVD2-Ig



α



β

