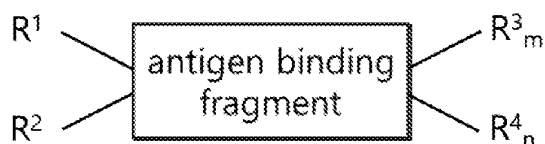


WHAT IS CLAIMED IS:

1. A multispecific antibody comprising a structural formula of:



wherein the antigen binding fragment (Fab) is a serum albumin Fab;

wherein  $R^1$  and  $R^2$  are bioactive effector moieties linked to an N-terminus of the Fab, each linked to a heavy chain variable domain or a light chain variable domain of the Fab;

wherein  $R^3$  and  $R^4$  are bioactive effector moieties linked to a C-terminus of the Fab, each linked to a heavy chain variable domain or a light chain variable domain of the Fab;

wherein m is 0 or an integer of 1 or greater; and

wherein n is 0 or an integer of 1 or greater.

2. The antibody of claim 1, wherein  $R^1$  and  $R^2$  are same or different single-chain variable fragments (scFv).

3. The antibody of claim 1 or 2, wherein  $R^3$  and  $R^4$  are same or different Fv fragments or disulfide-stabilized Fv (dsFv) fragments.

4. The antibody of any of claims 1-3, wherein each of  $R^1$ ,  $R^2$ ,  $R^3$ , and  $R^4$  is linked to the Fab by one or more linkers.

5. The antibody of any of claims 1-4, wherein the Fab comprises a heavy chain variable domain comprising

(a) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYGIS (SEQ ID NO:61),

a heavy chain CDR2 comprising the amino acid sequence of WINTYSGGTKYAQKFQG (SEQ ID NO:62), and

a heavy chain CDR3 comprising the amino acid sequence of LGHCQRGICSDALDT (SEQ ID NO:63);

- (b) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYGIS (SEQ ID NO:61),  
a heavy chain CDR2 comprising the amino acid sequence of RINTYNGNTGYAQLQG (SEQ ID NO:64), and  
a heavy chain CDR3 comprising the amino acid sequence of LGHCQRGICSDALDT (SEQ ID NO:63);
- (c) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of NYGIH (SEQ ID NO:65),  
a heavy chain CDR2 comprising the amino acid sequence of SISYDGSNKYYADSVKG (SEQ ID NO:66), and  
a heavy chain CDR3 comprising the amino acid sequence of DVHYYGSGSYNAFDI (SEQ ID NO:67);
- (d) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYAMS (SEQ ID NO:68),  
a heavy chain CDR2 comprising the amino acid sequence of VISHDGGFQYYADSVKG (SEQ ID NO:69), and  
a heavy chain CDR3 comprising the amino acid sequence of AGWLRQYGMDV (SEQ ID NO:70);
- (e) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYWIA (SEQ ID NO:71),  
a heavy chain CDR2 comprising the amino acid sequence of MIWPPDADARYSPSFQG (SEQ ID NO:72), and  
a heavy chain CDR3 comprising the amino acid sequence of LYSGSYSP (SEQ ID NO:73); or
- (f) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYSMN (SEQ ID NO:74),  
a heavy chain CDR2 comprising the amino acid sequence of SISSSGRYIHYADSVKG (SEQ ID NO:75), and  
a heavy chain CDR3 comprising the amino acid sequence of ETVMAGKALDY (SEQ ID NO:76).

6. The antibody of any of claims 1-5, wherein the Fab comprises a light chain variable domain comprising

- (g) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSI~~S~~RYLN (SEQ ID NO:77),  
a light chain CDR2 comprising the amino acid sequence of GASRL~~E~~S (SEQ ID NO:78), and  
a light chain CDR3 comprising the amino acid sequence of QQSDSV~~P~~VT (SEQ ID NO:79);
- (h) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSI~~S~~SYLN (SEQ ID NO:80),  
a light chain CDR2 comprising the amino acid sequence of AASSL~~Q~~S (SEQ ID NO:81), and  
a light chain CDR3 comprising the amino acid sequence of QQSYST~~P~~PPYT (SEQ ID NO:82);
- (i) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSIFNY~~V~~A (SEQ ID NO:83),  
a light chain CDR2 comprising the amino acid sequence of DASNRAT (SEQ ID NO:84), and  
a light chain CDR3 comprising the amino acid sequence of QQR~~S~~KWPPTWT (SEQ ID NO:85);
- (j) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASETVSSR~~Q~~LA (SEQ ID NO:86),  
a light chain CDR2 comprising the amino acid sequence of GASSRAT (SEQ ID NO:87), and  
a light chain CDR3 comprising the amino acid sequence of QQYGSS~~P~~RT (SEQ ID NO:88);
- (k) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVSS~~S~~SLA (SEQ ID NO:89),  
a light chain CDR2 comprising the amino acid sequence of GASSRAT (SEQ ID NO:87), and  
a light chain CDR3 comprising the amino acid sequence of QKYSSY~~P~~LT (SEQ ID NO:90); or
- (l) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVGSN~~L~~A (SEQ ID NO:91),  
a light chain CDR2 comprising the amino acid sequence of GASTGAT (SEQ ID NO:92), and

a light chain CDR3 comprising the amino acid sequence of QQYYSFLLAKT (SEQ ID NO:93).

7. The antibody of any of claims 1-6, wherein the Fab comprises

a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYSMN (SEQ ID NO:74), a heavy chain CDR2 comprising the amino acid sequence of SISSSGRYIHVADSVKG (SEQ ID NO:75), and a heavy chain CDR3 comprising the amino acid sequence of ETVMAGKALDY (SEQ ID NO:76), and

a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVGSNLA (SEQ ID NO:91), a light chain CDR2 comprising the amino acid sequence of GASTGAT (SEQ ID NO:92), and a light chain CDR3 comprising the amino acid sequence of QQYYSFLLAKT (SEQ ID NO:93).

8. The antibody of any of claims 1-7, wherein the Fab comprises a heavy chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:94, 95, 96, 97, 98, or 99.

9. The antibody of any of claims 1-8, wherein the Fab comprises a light chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:100, 101, 102, 103, 104, or 105.

10. The antibody of any of claims 1-9, wherein the Fab comprises a heavy chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:94, 95, 96, 97, 98, or 99, and a light chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:100, 101, 102, 103, 104, or 105, respectively.

11. The antibody of any of claims 1-10, wherein the Fab comprises a heavy chain domain comprising an amino acid sequence of SEQ ID NO:45 (V<sub>H</sub>-C<sub>H1</sub> domain) and a light chain domain comprising an amino acid sequence of SEQ ID NO:46 (V<sub>L</sub>-C<sub>L</sub> domain).

12. The antibody of any of claims 1-11, wherein each linker comprises 1 to 20 amino acids.

13. The antibody of any of claims 1-12, wherein each linker comprises an amino acid sequence having at least 90% identity to SEQ ID NO:3 or SEQ ID NO:4.

14. The antibody of any of claims 1-13, wherein each linker comprises an amino acid sequence of SEQ ID NO:3 or SEQ ID NO:4.

15. The antibody of any of claims 1-14, wherein each of the R<sup>1</sup> and R<sup>2</sup> is an anti-CD40L hu5c8 scFv.

16. The antibody of any of claims 1-15, wherein each of the R<sup>1</sup> and R<sup>2</sup> is an anti-CD40L hu5c8 scFv comprising an amino acid sequence having at least 80% identity to SEQ ID NO:47 or SEQ ID NO:48.

17. The antibody of any of claims 1-16, wherein each of the R<sup>1</sup> and R<sup>2</sup> is an anti-CD40L hu5c8 scFv comprising an amino acid sequence of SEQ ID NO:47 or SEQ ID NO:48.

18. The antibody of any of claims 1-17, wherein each of R<sup>3</sup> and R<sup>4</sup> is one or more bioactive effector moieties selected from the group consisting of anti-TNF- $\alpha$  Fv, anti-TNF- $\alpha$  disulfied-stabilized Fv (dsFv), anti-IL-23 Fv, anti-IL-23 dsFv, anti-IFNAR1, and anti-IFNAR1 dsFv.

19. The antibody of any of claims 1-18, wherein each of R<sup>3</sup> and R<sup>4</sup> is one or more bioactive effector moieties comprising an anti-TNF- $\alpha$  Fv comprising a heavy chain amino acid sequence having 80% identity to SEQ ID NO:49 and a light chain amino acid sequence having 80% identity to SEQ ID NO:50, anti-TNF- $\alpha$  disulfied-stabilized Fv (dsFv) comprising a heavy chain amino acid sequence having 80% identity to SEQ ID NO:51 and a light chain amino acid sequence having 80% identity to SEQ ID NO:52, anti-IL-23 Fv comprising a heavy chain amino acid sequence having 80% identity to SEQ ID NO:53 and a light chain amino acid sequence having 80% identity to SEQ ID NO:54, anti-IL-23 dsFv comprising a heavy chain amino acid sequence having 80% identity to SEQ ID NO:55 and a light chain amino acid sequence having 80% identity to SEQ ID NO:56, anti-IFNAR1 comprising a heavy chain amino acid sequence having 80% identity to SEQ ID NO:57 and a light chain amino acid sequence having 80% identity to SEQ ID NO:58, and/or anti-IFNAR1 dsFv comprising a heavy

chain amino acid sequence having 80% identity to SEQ ID NO:59 and a light chain amino acid sequence having 80% identity to SEQ ID NO:60.

20. The antibody of any of claims 1-19, wherein each of R<sup>3</sup> and R<sup>4</sup> is one or more bioactive effector moieties comprising an anti-TNF- $\alpha$  Fv comprising a heavy chain of SEQ ID NO:49 and a light chain of SEQ ID NO:50, anti-TNF- $\alpha$  disulfied-stabilized Fv (dsFv) comprising a heavy chain of SEQ ID NO:51 and a light chain of SEQ ID NO:52, anti-IL-23 Fv comprising a heavy chain of SEQ ID NO:53 and a light chain of SEQ ID NO:54, anti-IL-23 dsFv comprising a heavy chain of SEQ ID NO:55 and a light chain of SEQ ID NO:56, anti-IFNAR1 comprising a heavy chain of SEQ ID NO:57 and a light chain of SEQ ID NO:58, and/or anti-IFNAR1 dsFv comprising a heavy chain of SEQ ID NO:59 and a light chain of SEQ ID NO:60.

21. A composition comprising the multispecific antibody of any of claims 1-20 and an excipient.

22. A pharmaceutical composition comprising the multispecific antibody of any of claims 1-20 and a pharmaceutically accepted excipient.

23. A method of treating an autoimmune disease in a subject in need thereof, the method comprising administering the pharmaceutical composition of claim 22 to the subject.

24. An expression vector comprising:

- (a) a promoter,
- (b) a first nucleic acid molecule encoding an antigen binding fragment (Fab) that binds to serum albumin, and
- (c) a second nucleic acid molecule encoding a bioactive effector moiety and a linker,

wherein the promoter, the first nucleic acid sequence, and the second nucleic acid molecules are operably linked.

25. The vector of claim 24, wherein the second nucleic acid molecule encodes 2 or more bioactive effector moieties and linkers.

26. The vector of claim 24 or 25, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a heavy chain variable domain comprising

(a) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYGIS (SEQ ID NO:61),

a heavy chain CDR2 comprising the amino acid sequence of WINTYSGGTKYAQKFQG (SEQ ID NO:62), and

a heavy chain CDR3 comprising the amino acid sequence of LGHCQRGICSDALDT (SEQ ID NO:63);

(b) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYGIS (SEQ ID NO:61),

a heavy chain CDR2 comprising the amino acid sequence of RINTYNGNTGYAQLQG (SEQ ID NO:64), and

a heavy chain CDR3 comprising the amino acid sequence of LGHCQRGICSDALDT (SEQ ID NO:63);

(c) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of NYGIH (SEQ ID NO:65),

a heavy chain CDR2 comprising the amino acid sequence of SISYDGSNKYYADSVKG (SEQ ID NO:66), and

a heavy chain CDR3 comprising the amino acid sequence of DVHYYGSGSYNAFDI (SEQ ID NO:67);

(d) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of SYAMS (SEQ ID NO:68),

a heavy chain CDR2 comprising the amino acid sequence of VISHDGGFQYYADSVKG (SEQ ID NO:69), and

a heavy chain CDR3 comprising the amino acid sequence of AGWLRQYGMDV (SEQ ID NO:70);

(e) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYWIA (SEQ ID NO:71),

a heavy chain CDR2 comprising the amino acid sequence of MIWPPDADARYSPSFQG (SEQ ID NO:72), and

a heavy chain CDR3 comprising the amino acid sequence of LYSGSYSP (SEQ ID NO:73); or

- (f) a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYSMN (SEQ ID NO:74),  
a heavy chain CDR2 comprising the amino acid sequence of SISSSGRYIHVADSVKG (SEQ ID NO:75), and  
a heavy chain CDR3 comprising the amino acid sequence of ETVMAGKALDY (SEQ ID NO:76).

27. The vector of any of claims 24-26, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a light chain variable domain comprising

- (g) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQISRYLN (SEQ ID NO:77),  
a light chain CDR2 comprising the amino acid sequence of GASRLS (SEQ ID NO:78), and  
a light chain CDR3 comprising the amino acid sequence of QQSDSVPVT (SEQ ID NO:79);  
(h) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSISSYLN (SEQ ID NO:80),  
a light chain CDR2 comprising the amino acid sequence of AASSLQS (SEQ ID NO:81), and  
a light chain CDR3 comprising the amino acid sequence of QQSYSTPPYT (SEQ ID NO:82);  
(i) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSIFNYVA (SEQ ID NO:83),  
a light chain CDR2 comprising the amino acid sequence of DASNRAT (SEQ ID NO:84), and  
a light chain CDR3 comprising the amino acid sequence of QQRSKWPPTWT (SEQ ID NO:85);  
(j) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASETVSSRQLA (SEQ ID NO:86),  
a light chain CDR2 comprising the amino acid sequence of GASSRAT (SEQ ID NO:87), and  
a light chain CDR3 comprising the amino acid sequence of QQYGSSPRT (SEQ ID NO:88);

- (k) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVSSSLA (SEQ ID NO:89),  
a light chain CDR2 comprising the amino acid sequence of GASSRAT (SEQ ID NO:87), and  
a light chain CDR3 comprising the amino acid sequence of QKYSSYPLT (SEQ ID NO:90); or
- (l) a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVGSNLA (SEQ ID NO:91),  
a light chain CDR2 comprising the amino acid sequence of GASTGAT (SEQ ID NO:92), and  
a light chain CDR3 comprising the amino acid sequence of QQYYSFLAKT (SEQ ID NO:93).

28. The vector of any of claims 24-27, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising

a heavy chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of AYSMN (SEQ ID NO:74), a heavy chain CDR2 comprising the amino acid sequence of SISSSGRYIHADSVKG (SEQ ID NO:75), and a heavy chain CDR3 comprising the amino acid sequence of ETVMAGKALDY (SEQ ID NO:76), and

a light chain complementarity determining domain 1 (CDR1) comprising the amino acid sequence of RASQSVGSNLA (SEQ ID NO:91), a light chain CDR2 comprising the amino acid sequence of GASTGAT (SEQ ID NO:92), and a light chain CDR3 comprising the amino acid sequence of QQYYSFLAKT (SEQ ID NO:93).

29. The vector of any of claims 24-28, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a heavy chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:94, 95, 96, 97, 98, or 99.

30. The vector of any of claims 24-29, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a light chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:100, 101, 102, 103, 104, or 105.

31. The vector of any of claims 24-30, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a heavy chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:94, 95, 96, 97, 98, or 99, and a light chain variable domain comprising an amino acid sequence having at least 80% identity to SEQ ID NO:100, 101, 102, 103, 104, or 105, respectively.

32. The vector of any of claims 24-31, wherein the first nucleic acid molecule comprises a nucleic acid sequence encoding a Fab comprising a heavy chain domain comprising an amino acid sequence of SEQ ID NO:45 ( $V_H$ - $C_{H1}$  domain) and a light chain domain comprising an amino acid sequence of SEQ ID NO:46 ( $V_L$ - $C_L$  domain).

33. The vector of any of claims 24-32, wherein the bioactive effector moieties are anti-TNF- $\alpha$  Fv, anti-TNF- $\alpha$  dsFv, anti-IL-23 Fv, anti-IL-23 dsFv, anti-IFNAR1 Fv, and/or anti-IFNAR1 dsFv.

34. The vector of any of claims 23-33, wherein the second nucleic acid molecule comprises a nucleotide sequence encoding the amino acid sequence of one or more of SEQ ID NOs: 49-60.