

Claims

1. An isolated antibody, or antigen-binding portion thereof that specifically binds to canine or feline Oncostatin M receptor Beta (OSMR- β) or both, wherein the antibody antagonizes IL-31-mediated signaling or OSM-mediated signaling or both in a canine and/or feline cell.
2. The antibody, or antigen-binding portion thereof of claim 1, wherein the antibody antagonizes both IL-31-mediated signaling and OSM-mediated signaling in a canine and/or feline cell.
3. The antibody, or antigen-binding portion thereof of claim 1 or claim 2, comprising a combination of complementary determining region (CDR) sequences selected from the group consisting of:
 - 1) 02D09: variable heavy (VH)-CDR1 of SEQ ID NO: 1 (DYGMH), VH-CDR2 of SEQ ID NO: 2 (YISSGSRAVFFADTVKG), VH-CDR3 of SEQ ID NO: 3 (DRYDGRGFAY), variable light (VL)-CDR1 of SEQ ID NO: 4 (RASQSIENNHL), VL-CDR2 of SEQ ID NO: 5 (YASQSI), and VL-CDR3 of SEQ ID NO: 6 (QQSNSWPLT);
 - 2) 09E09: VH-CDR1 of SEQ ID NO: 7 (SYAMS), VH-CDR2 of SEQ ID NO: 8 (YISSGGDYIYYADTVKG), VH-CDR3 of SEQ ID NO: 9 (DPITGTFAY), VL-CDR1 of SEQ ID NO: 10 (RASQDINNYLN), VL-CDR2 of SEQ ID NO: 11 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 12 (QQGNTLPWT);
 - 3) 10F07: VH-CDR1 of SEQ ID NO: 13 (SYAMS), VH-CDR2 of SEQ ID NO: 14 (YISSGGDYFYADTVKG), VH-CDR3 of SEQ ID NO: 15 (DPITGTFAY), VL-CDR1 of SEQ ID NO: 16 (RASQDITNYLN), VL-CDR2 of SEQ ID NO: 17 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 18 (QQGHMLPWT);
 - 4) 14C04: VH-CDR1 of SEQ ID NO: 19 (NYWMN), VH-CDR2 of SEQ ID NO: 20 (QIYPGHVNTNYNGNFKD), VH-CDR3 of SEQ ID NO: 21 (SADNSGFVLFAY), VL-CDR1 of SEQ ID NO: 22 (RASKSVSTSGYSYLH), VL-CDR2 of SEQ ID NO: 23 (LASNLES), and VL-CDR3 of SEQ ID NO: 24 (QHSRELPLT);
 - 5) 19F07: VH-CDR1 of SEQ ID NO: 25 (DYDMA), VH-CDR2 of SEQ ID NO: 26 (NINYDGSSTYYLDSLKS), VH-CDR3 of SEQ ID NO: 27 (GLTWDFDV), VL-CDR1 of SEQ ID NO: 28 (KASQDVDTAVA), VL-CDR2 of SEQ ID NO: 29 (LASTRHT), and VL-CDR3 of SEQ ID NO: 30 (QQYSRFPLT); or
 - 6) CDR variants of 1, 2, 3, 4, or 5.
4. The antibody of any one of claims 1 to 3, comprising at least one of the group consisting of:

(a) a variable heavy chain comprising

SEQ ID NO: 31 (MU_02D09_VH)

EVQLVESGGGLVKPGGSLTSCAASGFTFSDYGMHWLRQAPEKGLEWVAYISSGSRAVFFAD
TVKGRFTISRDNANTLFLQMTSLRSDDTAMYYCARDRYDGRGFAYWGQGTTLTVSA,

SEQ ID NO: 35 (MU_09E09_VH)

DVKLVESGEGLVKPGGSLKLSCAASGFTFSSYAMSWVRQTPEKRLEWVAYISSGGDYIYYADT
VKGRFTISRDNARNTLYLQMSSLKSEDTAMYYCTRDPITGTFAYWGQGTTLTVSA,

SEQ ID NO: 39 (MU_10F07_VH)

DVKLVESGEGLVKPGGSLKLSCAASGFTFSSYAMSWVRQTPEKRLEWVTYISSGGDYFYFAD
TVKGRFTISRDNARNTLYLQMSSLKSEDTAMYYCTRDPITGTFAYWGQGTTLTVSA,

SEQ ID NO: 43 (MU_14C04_VH)

EVQLQESGAELVKPGASVKISCKASGYAFSNIWMNWMKQRPKGKLEWIGQIYPGHVNTNYN
GNFKDKATLTADK
SSSTAYMQLSSLTSEDSAVYFCARSADNSGFVLFAYWGQGTTLTVS,

SEQ ID NO: 47 (MU_19F07_VH)

EVKLVESEGGLVQPGSSMKLSCTASGFTFSDYYMAWVRQVPEKGLEWVANINYDGSSTYYLD
SLKSRFIISRDNANKNILYLQMSSLKSEDTATYYCARGLTWDFDVWGTGTTTVTVSS,

SEQ ID NO: 51 (FEL_02D09_VH1)

DVQLVESGGDLVKPGGSLRLTCVASGFTYSDYGMHWVRQAPGKGLQWVAYISSGSRAVFFA
DTVKGRFTISRDNANTLYLQMNSLKTEDTATYYCVRDRYDGRGFAYWGQGTTLTVTVSS,

SEQ ID NO: 53 (FEL_02D09_VH2)

DVQLVESGGDLVKPGGSLRLTCVASGFTFSDYGMHWVRQAPGKGLQWVAYISSGSRAVFFA
DTVKGRFTISRDNANTLYLQMNSLRRTEDTATYYCARDRYDGRGFAYWGQGTTLTVTVSS,

SEQ ID NO: 59 (CAN_09E09_VH1)

EVQLVESGGDLVKPGGSLRLSCVASGFTFSSYAMSWVRQAPGKGLQWVAYISSGGDYIYYAD
TVKGRFTISRDNANTLYLQMNSLRAEDTAMYYCVRDPITGTFAYWGQGTTLTVTVSS,

SEQ ID NO: 61 (CAN_09E09_VH2)

EVQLVESGGDLVKPAGSLTSLCLASGFTFSSYAMSWVRQTPEKGLQWVAYISSGGDYIYYADT
VKGRFTISRDNANTLYLQMNSLRDEDTAVYYCARDPITGTFAYWGQGTTLTVTVSS,

SEQ ID NO: 67 (FEL_09E09_VH1)

DVQLVESGGDLVKPGGSLRLTCVASGFTYSSYAMSWVRQAPGKGLQWVAYISSGGDYIYYAD
TVKGRFTISRDNANTLYLQMNSLKTEDTATYYCVRDPITGTFAYWGQGTTLTVTVSS,

SEQ ID NO: 69 (FEL_09E09_VH2)

DVQLVESGGNLVKPGGSLRLTCVASGFTFSSYAMSWVRQAPGKGLQWVAYISSGGDYIYYAD
TVKGRFTISKDNANTLYLQMNSLKTEDTATYYCARDPITGTFAYWGQGTTLTVTVSS,

SEQ ID NO: 75 (CAN_10F07_VH1)

EVQLVESGGDLVKPGGSLRLSCVASGFTFSSYAMSWVRQAPGKGLQWVAYISSGGDYFYFA
DTVKGRFTISRDNANTLYLQMNSLRAEDTAMYYCVRDPITGTFAYWGQGTTLTVTVSS,

SEQ ID NO: 79 (CAN_10F07_VH2)

EVQLVESGGDLVKPAGSLTSLCLASGFTFSSYAMSWVRQTPEKGLQWVAYISSGGDYFYAD
TVKGRFTISRDNANTLYLQMNSLRDEDTAVYYCARDPITGTFAYWGQGTLLTVSS,

SEQ ID NO: 83 (FEL_10F07_VH1)

DVQLVESGGDLVKPGGSLRLTCVASGFTYSSYAMSWVRQAPGKGLQWVAYISSGGDYFYA
DTVKGRFTISRDNANTLYLQMNSLKTEDTATYYCVRDPITGTFAYWGQGTLLTVSS,

SEQ ID NO: 87 (FEL_10F07_VH2)

DVQLVESGGDLVKPGGSLRLTCVASGFTFSSYAMSWVRQAPGKGLQWVAYISSGGDYFYA
DTVKGRFTISRDDAKNTLYLQMSSLKTEDTATYYCTGDPITGTFAYWGQGTLLTVSS,

SEQ ID NO: 91 (CAN_19F07_VH1)

EVQLVESGGDLVKPGGSLRLSCVASGFTFSDYYMAWVRQAPGKGLQWVANINYDGSSTYYLD
SLKSRFTISRDNANTLYLQMNSLRAEDTAMYYCVRGLTWDFDVWGQGTLLTVSS,

SEQ ID NO: 95 (CAN_19F07_VH2)

EVQLVESGGDLVKPAGSLTSLCLASGFTFSDYYMAWVRQTPEKGLQWVANINYDGSSTYYLD
SLKSRFTISRDNANTLYLQMNSLRDEDTAVYYCARGLTWDFDVWGQGTLLTVSS,

SEQ ID NO: 99 (FEL_19F07_VH1)

DVQLVESGGDLVKPGGSLRLTCVASGFTYSDYYMAWVRQAPGKGLQWVANINYDGSSTYYL
DSLKSRFTISRDNANTLYLQMNSLKTEDTATYYCVRGLTWDFDVWGQGTLLTVSS,

SEQ ID NO: 103 (FEL_19F07_VH2)

DVQLVESGGDLVKPGGSLRLTCVASGFTFSDYYMAWVRQAPGKGLQWVANINYDGSSTYYLD
SLKSRFTISRDNANTLYLQMNSLKTEDTATYYCARGLTWDFDVWGQGTLLTVSS,

SEQ ID NO: 127. (CAN_14C04_VH1)

EVQLVESGGDLVKPGGSLRLSCVASGFTFSNYWMNWVRQAPGKGLQWVAQIYPGHVNTNYN
GNFKDRFTISRDNARNTVYLQMNSLRAEDTAVYYCARSADNSGFVLFAYWGQGTLLTVSS, or

SEQ ID NO: 129. (CAN_14C04_VH2)

EVQLVESGGDLVKPGGSLRLSCVASGFTFSNYWMNWVRQSPGKGLQWVAQIYPGHVNTNYN
GNFKDRFTISRDNANTLYLQMNSLRAEDTAVYFCARSADNSGFVLFAYWGQGTLLTVSS;
and

(b) a variable light chain comprising

SEQ ID NO: 33 (MU_02D09_VL)

DIVLTQSPATLSVTPGDSVSLSCRASQSSNNLHWYQQTSHEPRLLITYASQSSISGIPSRFSGS
GSGTDFTLSINSVETEDFGMYFCQQSNSWPLTFGAGTKLELK,

SEQ ID NO: 37 (MU_09E09_VL)

DLQMTQTSSLSASLGDRVTISCRASQDINNYLNWYQQKPDGTVKLLIYYTSTLHSGVPSRFSG
SGSGTDYSLTISNLEQEDIATYFCQQGNTLPWTFGGGKLEIK,

SEQ ID NO: 41 (MU_10F07_VL)

DIQMTQTSSLSASLGDRVTISCRASQDITNYLNWYQQKPDGTVKLLIYYTSTLHSGVPSRFSG
SGSGTDFSLTISNLEQEDIATYFCQQGHMLPWTFGGGKLEIK,

SEQ ID NO: 45 (MU_14C04_VL)

DIVLTQSPASLAVSLGQRATISCRASKSVSTSGYSYLHWYQQKPGQPPKLLIFLASNLESGVPA
RFSGSGSGTDFTLNIHPVEEEDAATYYCQHSRELPLTFGAGTKLELK,

SEQ ID NO: 49 (MU_19F07_VL)

DIVMTQSHKFMSPSVGDRVSITCKASQDVDTAVAWYQQKPGQSPKLLIYLASTRHTGVPDRFT
GSGSGTDFTLTISNVQSEDLADYFCQQYSRFPLTFGAGTKLELK,

SEQ ID NO: 55 (FEL_02D09_VL1)

EIQMTQSPSSLSASPGDRVTITCRASQSSISNNLHWYQQKPGKVPKLLIYYASQSSISGVPSRFSG
SGSGTDFTLTISSELEPEDAATYYCQQSNSWPLTFGQGT,

SEQ ID NO: 57 (FEL_02D09_VL2)

DIVMTQTPLSLSVTPGESASISCRASQSSISNNLHWYLLQKSGQSPRRLIYYASQSSISGVPDRLFSG
SGSGTDFTLRISRVEADDVGYYCQQSNSWPLTFGQGT,

SEQ ID NO: 63 (CAN_09E09_VL1)

EIVMTQSPASLSLSQEEKVTITCRASQDINNYLNWYQQKPGQAPKLLIYYTSTLHSGVPSRFSG
SGSGTDFSFTISSELEPEDVAVYYCQQGNTLPWTFGQGT,

SEQ ID NO: 65 (CAN_09E09_VL2)

DIVLTQPTSVSGSLGQRVTISCRASQDINNYLNWYQQLPKGKAPKLLVYYTSTLHSGVPDRFSGS
NSGSSATLTITGLQAEDEADYYCQQGNTLPWTFGQGT,

SEQ ID NO: 71 (FEL_09E09_VL1)

EIQMTQSPSSLSASPGDRVTITCRASQDINNYLNWYQQKPGKVPKLLIYYTSTLHSGVPSRFSG
SGSGTDFTLTISSELEPEDAATYYCQQGNTLPWTFGQGT,

SEQ ID NO: 73 (FEL_09E09_VL2)

DITMTQSPGSLAGSPGQQVTMNCRASQDINNYLNWYQQKPGQHPKLLIYYTSTLHSGVPDRF
SGSGSGTDFTLTISNLQAEDVASYYCQQGNTLPWTFGQGT,

SEQ ID NO: 77 (CAN_10F07_VL1)

EIVMTQSPASLSLSQEEKVTITCRASQDITNYLNWYQQKPGQAPKLLIYYTSTLHSGVPSRFSG
SGSGTDFSFTISSELEPEDVAVYYCQQGHMLPWTFGQGT,

SEQ ID NO: 81 (CAN_10F07_VL2)

DIVLTQPTSVSGSLGQRVTISCRASQDITNYLNWYQQLPKGKAPKLLVYYTSTLHSGVPDRFSGS
NSGSSATLTITGLQAEDEADYYCQQGHMLPWTFGQGT,

SEQ ID NO: 85 (FEL_10F07_VL1)

EIQMTQSPSSLSASPGDRVTITCRASQDITNYLNWYQQKPGKVPKLLIYYTSTLHSGVPSRFSG
SGSGTDFTLTISSELEPEDAATYYCQQGHMLPWTFGQGT,

SEQ ID NO: 89 (FEL_10F07_VL2)

DITMTQSPGSLAGSPGQQVTMNCRASQDITNYLNWYQQKPGQHPKLLIYYTSTLHSGVPDRFS
GSGSGTDFTLTISNLQAEDVASYYCQQGHMLPWTFGQGT,

SEQ ID NO: 93 (CAN_19F07_VL1)

EIVMTQSPASLSLSQEEKVTITCKASQDVDTAVAWYQQKPGQAPKLLIYLASTRHTGVPSRFSG
SGSGTDFSFTISSELEPEDVAVYYCQQYSRFPLTFGQGT,

SEQ ID NO: 97 (CAN_19F07_VL2)
 DIVMTQTPLSLSVSPGETASISCKASQDVDTAVAWFRQKPGQSPQRLLIYLA STRHTGVPDRFS
 GSGSGTDFTLRISRVEADDTGVYYCQQYSRFPLTFGQGT,

SEQ ID NO: 101 (FEL_19F07_VL1)
 EIQMTQSPSSLSASPGDRVTITCKASQDVDTAVAWYQQKPGKVPKLLIYLA STRHTGVPSRFS
 GSGSGTDFTLTISSLEPEDAATYYCQQYSRFPLTFGQGT,

SEQ ID NO: 105 (FEL_19F07_VL2)
 DITMTQSPGSLAGSPGQQVTMNCASQDVDTAVAWYQQKPGQHHPKLLIYLA STRHTGVPDRF
 SSGSGTDFTLTISNLQAEDVASYYCQQYSRFPLTFGQGT,

SEQ ID NO: 131. (CAN_14C04_VL1)
 EIVMTQSPASLSLSQEEKVTITCRASKSVSTSGYSYLHWYQQKPGQAPKLLIYLA SNLESGVPS
 RFSGSGSGTDFSFTISSLEPEDVAVYYCQHSRELPLTFGQGT, or

SEQ ID NO: 133. (CAN_14C04_VL2)
 DIVMTQTPLSLSVSPGETASISCRASKSVSTSGYSYLHWY LQKPGQSPQLLIYLA SNLESGVSK
 RFSGSGSGTDFTLRISRVEADDTGIYYCQHSRELPLTFGQGT.

5. The antibody of any one of claims 1 to 4, wherein the antibody is chimeric.
6. The antibody of any one of claims 1 to 4, wherein the antibody is caninized or felinized.
7. The antibody of any one of claims 1 to 4, wherein the antibody inhibits or neutralizes an IL-31-mediated or OSM-mediated pruritic or allergic condition in a dog or cat.
8. The antibody of claim 7, wherein the IL-31-mediated or OSM-mediated pruritic condition is selected from the group consisting of atopic dermatitis, eczema, psoriasis, scleroderma, and pruritis.
9. The antibody of claim 8, wherein the IL-31-mediated or OSM-mediated allergic condition is selected from the group consisting of allergic dermatitis, summer eczema, urticaria, heaves, inflammatory airway disease, recurrent airway obstruction, airway hyper-responsiveness, chronic obstruction pulmonary disease, and inflammatory processes resulting from autoimmunity.
10. The antibody of any one of claims 1 to 4, wherein the antibody inhibits an IL-31-mediated or OSM-mediated fibrotic or inflammatory disorder.

11. The antibody of claim 10, wherein the IL-31-mediated or OSM-mediated fibrotic disorder is selected from the group consisting of renal fibrosis, pulmonary fibrosis, and dermal fibrosis.
12. The antibody of claim 10, wherein the IL-31-mediated or OSM-mediated inflammatory disorder is selected from the group consisting of inflammatory processes resulting from autoimmunity, inflammation in the skin or joint of animals affected by osteoarthritis, immune-mediated polyarthritis, chronic bronchitis, allergic asthma, atopic dermatitis, allergic dermatitis, pyotraumatic dermatitis, atherosclerosis, and cardiovascular disease.
13. The antibody of any one of claims 1 to 4, wherein the antibody reduces IL-31-mediated or OSM-mediated inflammatory pain.
14. The antibody of claim 13, wherein the IL-31-mediated or OSM-mediated inflammatory pain is osteoarthritis pain.
15. A veterinary composition comprising a therapeutically effective amount of the antibody of any one of claims 1 to 4.
16. Use of an antibody according to any one of claims 1 to 4 in the manufacture of a medicament for ~~A method of treating an IL-31-mediated or OSM-mediated disorder in a subject, comprising administering an antibody of any one of claims 1 to 4 to the subject.~~
17. The ~~method~~ use of claim 16, wherein the IL-31-mediated or OSM-mediated disorder is selected from the group consisting of a pruritic condition, an allergic condition, a fibrotic disorder, an inflammatory disorder, and inflammatory pain.
18. The ~~method~~ use of claim 17, wherein the IL-31-mediated or OSM-mediated pruritic condition is selected from the group consisting of atopic dermatitis, eczema, psoriasis, scleroderma, and pruritis.
19. The ~~method~~ use of claim 17, wherein the IL-31-mediated or OSM-mediated allergic condition is selected from the group consisting of allergic dermatitis, summer eczema, urticaria, heaves, inflammatory airway disease, recurrent airway obstruction, airway

hyper-responsiveness, chronic obstruction pulmonary disease, and inflammatory processes resulting from autoimmunity.

20. The ~~method~~ use of claim 17, wherein the IL-31-mediated or OSM-mediated fibrotic disorder is selected from the group consisting of renal fibrosis, pulmonary fibrosis, and dermal fibrosis.
21. The ~~method~~ use of claim 17, wherein the IL-31-mediated or OSM-mediated inflammatory disorder is selected from the group consisting of inflammatory processes resulting from autoimmunity, inflammation in the skin or joint of animals affected by osteoarthritis, immune-mediated polyarthritis, chronic bronchitis, allergic asthma, atopic dermatitis, allergic dermatitis, pyotraumatic dermatitis, atherosclerosis, and cardiovascular disease.
22. The ~~method~~ use of claim 17, wherein the IL-31-mediated or OSM-mediated inflammatory pain is osteoarthritis pain.
23. The ~~method~~ use of any one of claims 16 to 22, wherein the subject is a dog or a cat.
24. Use of an antibody according to any one of claims 1 to 4 in the manufacture of a medicament for ~~A method of inhibiting IL-31 and/or OSM activity in a dog or cat comprising administering an antibody according to any one of claims 1 to 4 to the dog or cat.~~
25. A method of detecting OSMR Beta in a sample comprising:
 - a) incubating a sample comprising OSMR Beta in the presence of an antibody according to any one of claims 1 to 4; and
 - b) detecting the antibody which is bound to OSMR Beta in the sample.
26. The method of claim 25, wherein the antibody comprises a label.
27. The method of claim 25 or claim 26, further comprising quantitating the OSMR Beta in the sample.

28. A host cell that produces an isolated antibody or antigen-binding portion thereof comprising at least one of the following combinations of complementary determining region (CDR) sequences:

- 1) 02D09: variable heavy (VH)-CDR1 of SEQ ID NO: 1 (DYGMH), VH-CDR2 of SEQ ID NO: 2 (YISSGSRAVFFADTVKG), VH-CDR3 of SEQ ID NO: 3 (DRYDGRGFAY), variable light (VL)-CDR1 of SEQ ID NO: 4 (RASQSI>NNLH), VL-CDR2 of SEQ ID NO: 5 (YASQSI), and VL-CDR3 of SEQ ID NO: 6 (QQSNSWPLT);
- 2) 09E09: VH-CDR1 of SEQ ID NO: 7 (SYAMS), VH-CDR2 of SEQ ID NO: 8 (YISSGGDYIYYADTVKG), VH-CDR3 of SEQ ID NO: 9 (DPITGTFAY), VL-CDR1 of SEQ ID NO: 10 (RASQDINNYLN), VL-CDR2 of SEQ ID NO: 11 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 12 (QQGNTLPWT);
- 3) 10F07: VH-CDR1 of SEQ ID NO: 13 (SYAMS), VH-CDR2 of SEQ ID NO: 14 (YISSGGDYFYADTVKG), VH-CDR3 of SEQ ID NO: 15 (DPITGTFAY), VL-CDR1 of SEQ ID NO: 16 (RASQDITNYLN), VL-CDR2 of SEQ ID NO: 17 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 18 (QQGHMLPWT);
- 4) 14C04: VH-CDR1 of SEQ ID NO: 19 (NYWMN), VH-CDR2 of SEQ ID NO: 20 (QIYPGHVNTNYNGNFKD), VH-CDR3 of SEQ ID NO: 21 (SADNSGFVLFAY), VL-CDR1 of SEQ ID NO: 22 (RASKSVSTSGYSYLH), VL-CDR2 of SEQ ID NO: 23 (LASNLES), and VL-CDR3 of SEQ ID NO: 24 (QHSRELPLT);
- 5) 19F07: VH-CDR1 of SEQ ID NO: 25 (DYMA), VH-CDR2 of SEQ ID NO: 26 (NINYDGSSTYYLDSLKS), VH-CDR3 of SEQ ID NO: 27 (GLTWDFDV), VL-CDR1 of SEQ ID NO: 28 (KASQDVDTAVA), VL-CDR2 of SEQ ID NO: 29 (LASTRHT), and VL-CDR3 of SEQ ID NO: 30 (QQYSRFPLT); or
- 6) CDR variants of 1, 2, 3, 4, or 5.

29. An isolated nucleic acid comprising a nucleic acid sequence encoding at least one of the following combinations of complementary determining region (CDR) sequences:

- 1) 02D09: variable heavy (VH)-CDR1 of SEQ ID NO: 1 (DYGMH), VH-CDR2 of SEQ ID NO: 2 (YISSGSRAVFFADTVKG), and VH-CDR3 of SEQ ID NO: 3 (DRYDGRGFAY);
- 2) 09E09: VH-CDR1 of SEQ ID NO: 7 (SYAMS), VH-CDR2 of SEQ ID NO: 8 (YISSGGDYIYYADTVKG), and VH-CDR3 of SEQ ID NO: 9 (DPITGTFAY);
- 3) 10F07: VH-CDR1 of SEQ ID NO: 13 (SYAMS), VH-CDR2 of SEQ ID NO: 14 (YISSGGDYFYADTVKG), and VH-CDR3 of SEQ ID NO: 15 (DPITGTFAY);
- 4) 14C04: VH-CDR1 of SEQ ID NO: 19 (NYWMN), VH-CDR2 of SEQ ID NO: 20 (QIYPGHVNTNYNGNFKD), and VH-CDR3 of SEQ ID NO: 21 (SADNSGFVLFAY);
- 5) 19F07: VH-CDR1 of SEQ ID NO: 25 (DYMA), VH-CDR2 of SEQ ID NO: 26 (NINYDGSSTYYLDSLKS), and VH-CDR3 of SEQ ID NO: 27 (GLTWDFDV); or
- 6) CDR variants of 1, 2, 3, 4, or 5.

30. The nucleic acid of claim 29, further comprising a nucleic acid sequence encoding at least one of the following combinations of CDR sequences:

- 1) 02D09: variable light (VL)-CDR1 of SEQ ID NO: 4 (RASQSI~~SN~~NLH), VL-CDR2 of SEQ NO: 5 (YASQSI~~S~~), and VL-CDR3 of SEQ ID NO: 6 (QQS~~NS~~WPLT);
- 2) 09E09: VL-CDR1 of VL-CDR1 of SEQ ID NO: 10 (RASQDINNYLN), VL-CDR2 of SEQ ID NO: 11 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 12 (QQGNTLPWT);
- 3) 10F07: VL-CDR1 of SEQ ID NO: 16 (RASQDITNYLN), VL-CDR2 of SEQ ID NO: 17 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 18 (QQGHMLPWT);
- 4) 14C04: VL-CDR1 of SEQ ID NO: 22 (RASKSVSTSGYSYLH), VL-CDR2 of SEQ ID NO: 23 (LASNLES), and VL-CDR3 of SEQ ID NO: 24 (QHSRELPLT);
- 5) 19F07: VL-CDR1 of SEQ ID NO: 28 (KASQDVDTAVA), VL-CDR2 of SEQ ID NO: 29 (LASTRHT), and VL-CDR3 of SEQ ID NO: 30 (QQYSRFPLT); or
- 6) CDR variants of 1, 2, 3, 4, or 5.

31. A nucleic acid sequence encoding at least one of the following combinations of CDR sequences:

- 1) 02D09: variable light (VL)-CDR1 of SEQ ID NO: 4 (RASQSI~~SN~~NLH), VL-CDR2 of SEQ NO: 5 (YASQSI~~S~~), and VL-CDR3 of SEQ ID NO: 6 (QQS~~NS~~WPLT);
- 2) 09E09: VL-CDR1 of VL-CDR1 of SEQ ID NO: 10 (RASQDINNYLN), VL-CDR2 of SEQ ID NO: 11 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 12 (QQGNTLPWT);
- 3) 10F07: VL-CDR1 of SEQ ID NO: 16 (RASQDITNYLN), VL-CDR2 of SEQ ID NO: 17 (YTSTLHS), and VL-CDR3 of SEQ ID NO: 18 (QQGHMLPWT);
- 4) 14C04: VL-CDR1 of SEQ ID NO: 22 (RASKSVSTSGYSYLH), VL-CDR2 of SEQ ID NO: 23 (LASNLES), and VL-CDR3 of SEQ ID NO: 24 (QHSRELPLT);
- 5) 19F07: VL-CDR1 of SEQ ID NO: 28 (KASQDVDTAVA), VL-CDR2 of SEQ ID NO: 29 (LASTRHT), and VL-CDR3 of SEQ ID NO: 30 (QQYSRFPLT); or
- 6) CDR variants of 1, 2, 3, 4, or 5.

32. A vector comprising the nucleic acid of any one of claims 29, 30, or 31.

33. A method of producing an antibody comprising culturing the host cell of claim 28 under conditions that result in production of the antibody and isolating the antibody from the host cell or culture medium of the host cell.