AFUCOSYLATED ANTI-FGFR2IIIB ANTIBODIES

FIELD OF THE INVENTION

[0001] Afucosylated anti-FGFR2IIIb antibodies are provided.

BACKGROUND OF THE INVENTION

[0002] The fibroblast growth factor (FGF) family members bind to four known tyrosine kinase receptors, fibroblast growth factor receptors 1-4 (FGFR1-4) and their isoforms, with the various FGFs binding the different FGFRs to varying extents (Zhang et al., J. Biol. Chem. 281:15694, 2006). A protein sequence of human FGFR2 is provided in, *e.g.*, GenBank Locus AF487553. Each FGFR consists of an extracellular domain (ECD) comprising three immunoglobulin (Ig)-like domains (D1, D2 and D3), a single transmembrane helix, and an intracellular catalytic kinase domain (Mohammadi et al., Cytokine Growth Factor Revs, 16:107, 2005). There is a contiguous stretch of acidic amino acids in the linker between D1 and D2 called the "acid box" (AB). The region containing D1 and AB is believed to be involved in autoinhibition of the receptor, which is relieved by binding to ligand. FGFs bind to the receptors primarily through regions in D2 and D3 of the receptors. The FGFRs are characterized by multiple alternative splicing of their mRNAs, leading to a variety of isoforms (Ornitz et al., J. Biol. Chem. 271:15292, 1996; see also Swiss-Prot P21802 and isoforms P21802-1 to -20 for sequences of FGFR2 and its isoforms). Notably, there are forms containing all three Ig domains (α isoform) or only the two Ig domains D2 and D3 domains without D1 (β isoform). In FGFR1 - FGFR3, all forms contain the first half of D3 denoted IIIa, but two alternative exons can be utilized for the second half of D3, leading to IIIb and IIIc forms. For FGFR2, these are respectively denoted FGFR2IIIb and FGFR2IIIc (or just FGFR2b and FGFR2c); the corresponding beta forms are denoted FGFR2(beta)IIIb and FGFR2(beta)IIIc. The FGFR2IIIb form of FGFR2 (also denoted K-sam-II) is a high affinity receptor for both FGF1 and KGF family members (FGF7, FGF10, and FGF22) whereas FGFR2IIIc (also denoted K-sam-I) binds both FGF1 and FGF2 well but does not bind the KGF family members (Miki et al., Proc. Natl. Acad. Sci. USA 89:246, 1992). Indeed, FGFR2IIIb is the only receptor for KGF family members (Ornitz et al., 1996, *op. cit.*) and is therefore also designated KGFR.

[0003] The FGFRs and their isoforms are differentially expressed in various tissues. FGFR2IIIb (and the IIIb forms of FGFR1 and FGFR3) is expressed in epithelial tissues, while FGFRIIIc is expressed in mesenchymal tissues (Duan et al., J. Biol. Chem. 267:16076, 1992; Ornitz et al., 1996, *op. cit.*). Certain of the FGF ligands of these receptors have an opposite pattern of

expression. Thus, KGF subfamily members, including FGF7 (KGF), FGF10, and FGF22, bind only to FGFRIIIb (Zhang et al., *op. cit*.) and are expressed in mesenchymal tissues so may be paracrine effectors of epithelial cells (Ornitz et al., 1996, *op. cit*.). In contrast, the FGF4 subfamily members FGF4-6 bind to FGFR2IIIc and are expressed in both epithelial and mesenchymal lineages so may have either autocrine or paracrine functions. Because of the expression patterns of the isoforms of FGFR2 and their ligands, FGFR2 plays a role in epithelial-mesynchymal interactions (Finch et al., Dev. Dyn. 203:223, 1995), so it is not surprising that knock-out of FGFR2IIIb in mice leads to severe embryonic defects and lethality (De Moerlooze et al., Development 127:483, 2000).

[0004] KGF (FGF7) and KGFR (FGFR2IIIb) are overexpressed in many pancreatic cancers (Ishiwata et al., Am. J. Pathol. 153: 213, 1998), and their coexpression correlates with poor prognosis (Cho et al., Am. J. Pathol. 170:1964, 2007). Somatic mutations of the FGFR2 gene were found in 12% of a large panel of endometrial (uterine) carcinomas, and in several tested cases were required for tumor cell survival (Dutt et al., Proc. Natl. Acad. Sci. USA 105:8713, 2008). In two tumors the FGFR2 mutation was found to be the same S252W substitution associated with Apert syndrome. Amplification and overexpression of FGFR2 is associated with the undifferentiated, diffuse type of gastric cancer, which has a particularly poor prognosis, and inhibition of the FGFR2 activity by small molecule compounds potently inhibited proliferation of such cancer cells (Kunii et al., Cancer Res. 68:2340, 2008; Nakamura et al., Gastroenterol. 131:1530, 2006).

SUMMARY OF THE INVENTION

[0005] In once aspect, the present invention refers to a composition comprising a plurality of anti-FGFR2IIIb antibodies, wherein each anti-FGFR2IIIb antibody comprises heavy chain and light chain variable regions, wherein the heavy chain variable region comprises: (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (iii) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; and the light chain variable region comprises: (iv) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (v) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (vi) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11; wherein at least 95% of the anti-FGFR2IIIb antibodies in the composition are afucosylated. In one aspect, the present invention refers to a host cell comprising nucleic acid encoding anti-FGFR2IIIb antibodies disclosed herein, wherein the host cell lacks a functional alpha-1,6-fucosyltransferase gene (FUT8) gene. In another example, disclosed herein is a composition comprising a plurality of afucosylated anti-FGFR2IIIb antibodies, wherein the anti-FGFR2IIIb antibodies compete for binding to FGFR2IIIb with an antibody comprising a heavy chain variable region comprising the amino acid

sequence of SEQ ID NO: 4 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. In yet another example, disclosed herein is a host cell comprising nucleic acid encoding the anti-FGFR2IIIb antibody as disclosed herein, wherein the host cell lacks a functional alpha-1,6-fucosyltransferase gene (FUT8) gene. In yet another aspect, the present invention refers to a method for making afucosylated anti-FGFR2IIIb antibodies, said method comprising culturing the host cell as disclosed herein under conditions suitable for expressing the nucleic acid encoding the anti-FGFR2IIIb antibody. In a further aspect, the present invention refers to a method for making afucosylated anti-FGFR2IIIb antibodies, comprising culturing the host cell as disclosed herein under conditions suitable for producing afucosylated anti-FGFR2IIIb antibodies. In one aspect, the present invention refers to a pharmaceutical composition comprising the composition as disclosed herein and a pharmaceutically acceptable carrier. In another aspect, the present invention refers to use of a composition as disclosed herein or of a pharmaceutical composition as disclosed herein in the manufacture of a medicament for treating cancer in an individual in need thereof. In one aspect, the present invention refers to a pharmaceutical composition for treating cancer comprising an effective amount of anti-FGFR2IIIb antibodies as disclosed herein and a pharmaceutically acceptable carrier. In a further example, disclosed herein is a pharmaceutical composition for treating cancer in an individual comprising an effective amount of an anti-FGFR2IIIb antibody as disclosed herein and a pharmaceutically acceptable carrier. In some examples, an anti-FGFR2IIIb antibody is provided, wherein the heavy chain variable region comprises: (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (iii) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; and the light chain variable region comprises: (iv) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (v) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (vi) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11; wherein the antibody is afucosylated. In some examples, the antibody lack fucose at Asn297. In some examples, compositions comprising a plurality of anti-FGFR2IIIb antibodies are provided, wherein the heavy chain variable region of each anti-FGFR2IIIb antibody in the composition comprises: (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (iii) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; and the light chain variable region of each anti-FGFR2IIIb antibody in the composition comprises: (iv) HVR-L1

comprising the amino acid sequence of SEQ ID NO: 9; (v) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (vi) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11; wherein at least 95% of the antibodies in the composition are afucosylated. In some examples, the composition may be a supernatant from an antibody-producing cell line. In some examples, the composition may be a buffered composition. In some examples, the heavy chain variable domain comprises the amino acid sequence of SEQ ID NO: 4. In some examples, the light chain variable domain comprises the amino acid sequence of SEQ ID NO: 5. In some examples, the heavy chain variable domain comprises the amino acid sequence of SEQ ID NO: 4 and the light chain variable domain comprises the amino acid sequence of SEQ ID NO: 5. In some examples, the heavy chain comprises the amino acid sequence of SEQ ID NO: 2. In some examples, the light chain comprises the amino acid sequence of SEQ ID NO: 3. In some examples, the heavy chain comprises the amino acid sequence of SEQ ID NO: 2 and the light chain comprises the amino acid sequence of SEQ ID NO: 3. In some examples, a composition comprising a plurality of afucosylated anti-FGFR2IIIb antibodies is provided, wherein the antibodies compete for binding to FGFR2IIIb with an antibody comprising a heavy chain variable domain comprising the amino acid sequence of SEQ ID NO: 4 and a light chain variable domain comprising the amino acid sequence of SEQ ID NO: 5.

[0006] In some examples, the antibodies are monoclonal antibodies. In some examples, the antibodies are chimeric antibodies. In some examples, the antibodies are humanized antibodies. In any of the examples described herein, the antibodies may comprise a κ light chain constant region. In any of the examples described herein, the antibodies may comprise an IgG1 heavy chain constant region.

[0007] In some examples, the antibodies have enhanced ADCC activity *in vitro* compared to fucosylated anti-FGFR2IIIb antibodies having the same amino acid sequence. In some examples, the afucosylated anti-FGFR2IIIb antibodies cause specific lysis that is at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 60, at least 65, at least 70, or at least 75 percentage points greater than specific lysis with fucosylated anti-FGFR2IIIb antibodies. In some examples, ADCC activity is determined using Ba/F3 cells expressing FGFR2IIIb as target cells and isolated human PBMCs as effector cells.

[0008] In some examples, the antibodies have enhanced affinity for Fc gamma RIIIA compared to fucosylated anti-FGFR2IIIb antibodies having the same amino acid sequence. In some examples, the afucosylated anti-FGFR2IIIb antibodies bind to Fc gamma RIIIA with

at least 2-fold, at least 3-fold, at least 4-fold, at least 5-fold, at least 7-fold, at least 10-fold, at least 12-fold, at least 15-fold, at least 17-fold, or at least 20-fold greater affinity than fucosylated anti-FGFR2IIIb antibodies. In some examples, affinity for Fc gamma RIIIA is determined using surface plasmon resonance. In some examples, Fc gamma RIIIA is selected from Fc gamma RIIIA(V158) and Fc gamma RIIIA(F158). In some examples, Fc gamma RIIIA is Fc gamma RIIIA(V158).

[0009] In any of the examples described herein, the antibodies may bind FGFR2IIIb but not FGFR2IIIc.

[0010] In any of the examples described herein, a composition comprising a plurality of afucosylated anti-FGFR2IIIb antibodies comprises at least 95% afucosylated antibodies. In any of the examples described herein, a composition comprising a plurality of afucosylated anti-FGFR2IIIb antibodies may have undetectable fucosylation. In some examples, the presence of fucose may be determined by a method comprising high performance liquid chromatography (HPLC), capillary electrophoresis, or MALDI-TOF mass spectrometry.

[0011] In some examples, host cells are provided that comprise nucleic acid encoding an anti-FGFR2IIIb antibody described herein, wherein the host cell lacks a functional alpha-1,6-fucosyltransferase gene (FUT8) gene. In some examples, the host cell is a CHO cell.

[0012] In some examples, methods for making afucosylated anti-FGFR2IIIb antibodies are provided. In some examples, a method comprises culturing a host cell under conditions suitable for expressing nucleic acid encoding the anti-FGFR2IIIb antibody, wherein the host cell lacks a functional alpha-1,6-fucosyltransferase gene (FUT8) gene. In some examples, a method for making afucosylated anti-FGFR2IIIb antibodies comprises culturing the host cell under conditions suitable for producing the afucosylated anti-FGFR2IIIb antibody. In some examples, the method further comprises recovering the anti-FGFR2IIIb antibody produced by the host cell. In some examples, less than 5% of the anti-FGFR2IIIb antibodies produced by the host cell comprise fucose. In some examples, at least 95% of the anti-FGFR2IIIb antibodies produced by the host cell lack fucose (i.e., are afucosylated). In some examples, fucose is undetectable in the anti-FGFR2IIIb antibodies produced by the host cell. In some examples, presence of fucose is detected by a method comprising HPLC, capillary electrophoresis, or MALDI-TOF mass spectrometry.

[0013] In some examples, pharmaceutical compositions are provided, wherein the pharmaceutical composition comprises afucosylated anti-FGFR2IIIb antibodies described herein and a pharmaceutically acceptable carrier.

[0014] In some examples, methods of treating cancer are provided. In some examples, a method comprises administering an effective amount of a pharmaceutical composition comprising afucosylated anti-FGFR2IIIb antibodies described herein and a pharmaceutically acceptable carrier. In some examples, the cancer is selected from gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, and esophageal cancer. In some examples, the cancer is gastric cancer. In some examples, the cancer comprises an FGFR2 gene amplification. In some examples, FGFR2 amplification comprises FGFR2:CEN10 (chromosome 10 centromere) ratio of >3. In some examples, the cancer overexpresses FGFR2IIIb. In some examples, a cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some examples, a cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some examples, the expression levels are normalized to GUSB. In some examples, the cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some examples, expression or overexpression of FGFR2IIIb is determined by IHC. In some examples, 1+, 2+ or 3+ staining of tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, 2+ or 3+ staining in tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, the IHC staining is scored as described in Example 6.

[0015] In some examples, a method of treating cancer further comprises administering at least one additional therapeutic agent selected from a platinum agent, paclitaxel, ABRAXANE®, docetaxel, gemcitabine, capecitabine, irinotecan, epirubicin, FOLFOX, FOLFIRI, leucovorin, fluorouracil, mitomycin C, and doxorubicin hydrochloride. In some examples, the platinum agent is selected from cisplatin, oxaliplatin, and carboplatin. In some examples, a method of treating cancer further comprises administering paclitaxel. In some examples, a method of treating cancer further comprises administering cisplatin and/or 5-FU.

[0016] In some examples, uses of a pharmaceutical composition comprising afucosylated anti-FGFR2IIIb antibodies described herein and a pharmaceutically acceptable carrier are provided. In some examples, such use is for treating cancer in an individual with cancer. In some examples, the cancer is selected from gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, or esophageal cancer. In some examples, the cancer is gastric cancer. In some examples, the cancer comprises an FGFR2 gene amplification. In some examples, FGFR2 amplification

comprises FGFR2:CEN10 (chromosome 10 centromere) ratio of >3. In some examples, the cancer overexpresses FGFR2IIIb. In some

examples, a cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some examples, a cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some examples, the expression levels are normalized to GUSB. In some examples, the cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some examples, expression or overexpression of FGFR2IIIb is determined by IHC. In some examples, 1+, 2+ or 3+ staining of tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, 2+ or 3+ staining in tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, the IHC staining is scored as described in Example 6.

[0017] In some examples, pharmaceutical compositions for treating cancer are provided, wherein the pharmaceutical composition comprises afucosylated anti-FGFR2IIIb antibodies described herein and a pharmaceutically acceptable carrier. In some examples, the cancer is selected from gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, or esophageal cancer. In some examples, the cancer is gastric cancer. In some examples, the cancer comprises an FGFR2 gene amplification. In some examples, FGFR2 amplification comprises FGFR2:CEN10 (chromosome 10 centromere) ratio of >3. In some examples, the cancer overexpresses FGFR2IIIb. In some examples, a cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some examples, a cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some examples, the expression levels are normalized to GUSB. In some examples, the cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some examples, expression or overexpression of FGFR2IIIb is determined by IHC. In some examples, 1+, 2+ or 3+ staining of tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, 2+ or 3+ staining in tumor cells by IHC indicates FGFR2IIIb overexpression. In some examples, the IHC staining is scored as described in Example 6.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figure 1A to 1C shows ADCC activity of afucosylated αFGFR2bA and fucosylated αFGFR2bF against FGFR2IIIb-expressing Ba/F3 cells, as discussed in Example 3. In the legends, "αFGFR2bF / FGFR2b" indicates that fucosylated αFGFR2bF antibody was tested against FGFR2IIIb-expressing Ba/F3 target cells.

[0019] Figure 2A to 2D shows efficacy of afucosylated αFGFR2bA and fucosylated αFGFR2bF in an OCUM-2M gastric cancer xenograft model, at (A and B) 10 mg/kg and (C and D) 3 mg/kg, as discussed in Example 4.

[0020] Figure 3A and 3B shows dose-dependent efficacy of afucosylated αFGFR2bA in an OCUM-2M gastric cancer xenograft model, as discussed in Example 4.

[0021] Figure 4A and 4B shows efficacy of combination therapy with afucosylated αFGFR2bA and paclitaxel in an OCUM-2M gastric cancer xenograft model, as discussed in Example 4.

[0022] Figure 5A and 5B shows efficacy of combination therapy with afucosylated αFGFR2bA and 5-FU/cisplatin in an OCUM-2M gastric cancer xenograft model, as discussed in Example 4.

[0023] Figure 6A and 6B show efficacy of afucosylated αFGFR2bA in a MFM-223 breast cancer xenograft model, as discussed in Example 4.

[0024] Figure 7 shows the glycan profile of αFGFR2b antibody produced in (A) Potelligent® CHOK1SV cells and (B) CHOK1SV cells, as described in Example 1.

[0025] Figure 8 shows schematic diagrams of N-linked glycans typically found in antibodies.

[0026] Figure 9 shows ADCC of Ba/F3 FGF2b cells with increasing concentrations of αFGFR2bA or αFGFR2bF. Assays were performed with normal human PBMC at an E:T ratio of 25:1, as described in Example 5. Data are plotted as LDH release.

[0027] Figure 10 shows ADCC of OCUM-2M cells with increasing concentrations of αFGFR2bA or αFGFR2bF. Assays were performed with normal human PBMC at an E:T ratio of 25:1. As described in Example 5. Data are plotted as percent specific lysis.

[0028] Figure 11A to 11F shows detection of FGFR2IIIb in tumor tissue samples using immunohistochemistry, as described in Example 6.

DETAILED DESCRIPTION OF THE INVENTION

[0029] Afucosylated antibodies that bind FGFR2IIIb are provided. In some embodiments, afucosylated antibody heavy chains and light chains that are capable of forming antibodies that bind FGFR2IIIb are also provided. In some embodiments, afucosylated antibodies, heavy chains, and light chains comprising one or more particular hypervariable regions (HVRs) are provided. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced ADCC activity relative to fucosylated anti-FGFR2IIIb antibodies. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced affinity for Fc gamma RIIIA relative to fucosylated anti-FGFR2IIIb antibodies. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced affinity for Fc gamma RIIIA(V158) relative to fucosylated anti-FGFR2IIIb antibodies. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have

enhanced affinity for Fc gamma RIIIA(F158) relative to fucosylated anti-FGFR2IIIb antibodies. In some embodiments, afucosylated anti-FGFR2IIIb antibodies do not bind to FGFR2IIIc.

[0030] Polynucleotides encoding antibodies that bind FGFR2IIIb are provided. Polynucleotides encoding antibody heavy chains or lights chains are also provided. Host cells that express afucosylated anti-FGFR2IIIb antibodies are provided. Methods of treatment using afucosylated antibodies to FGFR2IIIb are provided. Such methods include, but are not limited to, methods of treating cancer, such as gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, and esophageal cancer.

[0031] The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[0032] All references cited herein, including patent applications, patent publications, and Genbank Accession numbers are herein incorporated by reference, as if each individual reference were specifically and individually indicated to be incorporated by reference in its entirety.

[0033] The techniques and procedures described or referenced herein are generally well understood and commonly employed using conventional methodology by those skilled in the art, such as, for example, the widely utilized methodologies described in Sambrook *et al.*, Molecular Cloning: A Laboratory Manual 3rd. edition (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. CURRENT PROTOCOLS IN MOLECULAR BIOLOGY (F. M. Ausubel, *et al. eds.*, (2003)); the series METHODS IN ENZYMOLOGY (Academic Press, Inc.): PCR 2: A PRACTICAL APPROACH (M. J. MacPherson, B. D. Hames and G. R. Taylor *eds.* (1995)), Harlow and Lane, *eds.* (1988) ANTIBODIES, A LABORATORY MANUAL, and ANIMAL CELL CULTURE (R. I. Freshney, *ed.* (1987)); Oligonucleotide Synthesis (M. J. Gait, ed., 1984); Methods in Molecular Biology, Humana Press; Cell Biology: A Laboratory Notebook (J. E. Cellis, *ed.*, 1998) Academic Press; Animal Cell Culture (R. I. Freshney), *ed.*, 1987); Introduction to Cell and Tissue Culture (J. P. Mather and P. E. Roberts, 1998) Plenum Press; Cell and Tissue Culture Laboratory Procedures (A. Doyle, J. B. Griffiths, and D. G. Newell, eds., 1993-8) J. Wiley and Sons; Handbook of Experimental Immunology (D. M. Weir and C. C. Blackwell, *eds.*); Gene Transfer Vectors for Mammalian Cells (J. M. Miller and M. P. Calos, *eds.*, 1987); PCR: The Polymerase Chain Reaction, (Mullis *et al.*, *eds.*, 1994); Current Protocols in Immunology (J. E. Coligan *et al.*, *eds.*, 1991); Short Protocols in Molecular Biology (Wiley and Sons, 1999); Immunobiology (C. A. Janeway and P. Travers, 1997); Antibodies (P. Finch, 1997); Antibodies: A Practical Approach (D. Catty., *ed.*, IRL Press, 1988-1989); Monoclonal Antibodies: A Practical Approach (P. Shepherd and C. Dean, *eds.*, Oxford University Press,

2000); Using Antibodies: A Laboratory Manual (E. Harlow and D. Lane (Cold Spring Harbor Laboratory Press, 1999); The Antibodies (M. Zanetti and J. D. Capra, *eds*., Harwood Academic Publishers, 1995); and Cancer: Principles and Practice of Oncology (V. T. DeVita *et al.*, *eds*., J.B. Lippincott Company, 1993); and updated versions thereof.

I. Definitions

[0034] Unless otherwise defined, scientific and technical terms used in connection with the present invention shall have the meanings that are commonly understood by those of ordinary skill in the art. Further, unless otherwise required by context or expressly indicated, singular terms shall include pluralities and plural terms shall include the singular.

[0035] It is understood that aspect and embodiments of the invention described herein include "consisting" and/or "consisting essentially of" aspects and embodiments. As used herein, the singular form "a", "an", and "the" includes plural references unless indicated otherwise.

[0036] In this application, the use of "or" means "and/or" unless expressly stated or understood by one skilled in the art. In the context of a multiple dependent claim, the use of "or" refers back to more than one preceding independent or dependent claim.

[0037] As is understood by one skilled in the art, reference to "about" a value or parameter herein includes (and describes) embodiments that are directed to that value or parameter per se. For example, description referring to "about X" includes description of "X".

[0038] The terms "nucleic acid molecule", "nucleic acid" and "polynucleotide" may be used interchangeably, and refer to a polymer of nucleotides. Such polymers of nucleotides may contain natural and/or non-natural nucleotides, and include, but are not limited to, DNA, RNA, and PNA. "Nucleic acid sequence" refers to the linear sequence of nucleotides that comprise the nucleic acid molecule or polynucleotide.

[0039] The terms "polypeptide" and "protein" are used interchangeably to refer to a polymer of amino acid residues, and are not limited to a minimum length. Such polymers of amino acid residues may contain natural or non-natural amino acid residues, and include, but are not limited to, peptides, oligopeptides, dimers, trimers, and multimers of amino acid residues. Both full-length proteins and fragments thereof are encompassed by the definition. The terms also include post-expression modifications of the polypeptide, for example, glycosylation, sialylation, acetylation, phosphorylation, and the like. Furthermore, for purposes of the present invention, a "polypeptide" refers to a protein which includes modifications, such as deletions, additions, and substitutions (generally conservative in nature), to the native sequence, as long as the protein maintains the desired activity. These modifications may be deliberate, as through site-directed

mutagenesis, or may be accidental, such as through mutations of hosts which produce the proteins or errors due to PCR amplification.

[0040] "FGFR2IIIb" or "FGFR2b" are used interchangeably to refer to the fibroblast growth factor receptor 2 IIIb splice form. An exemplary human FGFR2IIIb is shown in GenBank Accession No. NP_075259.4, dated July 7, 2013. A nonlimiting exemplary mature human FGFR2IIIb amino acid sequence is shown in SEQ ID NO: 1.

[0041] "FGFR2IIIc" or "FGFR2c" are used interchangeably to refer to the fibroblast growth factor receptor 2 IIIc splice form. An exemplary human FGFR2IIIc is shown in GenBank Accession No. NP_000132.3, dated July 7, 2013. A nonlimiting exemplary mature FGFR2IIIc amino acid sequence is shown in SEQ ID NO: 12.

[0042] The term "epitope" refers to a site on a target molecule (*e.g.*, an antigen, such as a protein, nucleic acid, carbohydrate or lipid) to which an antigen-binding molecule (*e.g.*, an antibody, antibody fragment, or scaffold protein containing antibody binding regions binds. Epitopes often consist of a chemically active surface grouping of molecules such as amino acids, polypeptides or sugar side chains and have specific three-dimensional structural characteristics as well as specific charge characteristics. Epitopes can be formed both from contiguous or juxtaposed noncontiguous residues (*e.g.*, amino acids, nucleotides, sugars, lipid moiety) of the target molecule. Epitopes formed from contiguous residues (*e.g.*, amino acids, nucleotides, sugars, lipid moiety) typically are retained on exposure to denaturing solvents whereas epitopes formed by tertiary folding typically are lost on treatment with denaturing solvents. An epitope may include but not limited to at least 3, at least 5 or 8-10 residues (*e.g.*, amino acids or nucleotides). In some examples an epitope is less than 20 residues (*e.g.*, amino acids or nucleotides) in length, less than 15 residues or less than 12 residues. Two antibodies may bind the same epitope within an antigen if they exhibit competitive binding for the antigen.

[0043] A "nonlinear epitope" or "conformational epitope" comprises noncontiguous polypeptides, amino acids and/or sugars within the antigenic protein to which an antibody specific to the epitope binds.

[0044] A "linear epitope" comprises contiguous polypeptides, amino acids and/or sugars within the antigenic protein to which an antibody specific to the epitope binds.

[0045] The term "antibody" herein is used in the broadest sense and encompasses various antibody structures, including but not limited to monoclonal antibodies, polyclonal antibodies, multispecific antibodies (*e.g.*, bispecific antibodies), and antibody fragments so long as they exhibit the desired antigen-binding activity.

[0046] The term antibody includes, but is not limited to, fragments that are capable of binding antigen, such as Fv, single-chain Fv (scFv), Fab, Fab', and $(Fab')_2$. Papain digestion of antibodies produces two identical antigen-binding fragments, called "Fab" fragments, each with a single antigen-binding site, and a residual "Fc" fragment, whose name reflects its ability to crystallize readily. Pepsin treatment yields an $F(ab')_2$ fragment that has two antigen-combining sites and is still capable of cross-linking antigen. The term antibody also includes, but is not limited to, chimeric antibodies, humanized antibodies, and antibodies of various species such as mouse, human, cynomolgus monkey, *etc.*

[0047] The term "heavy chain variable region" refers to a region comprising heavy chain HVR1, framework (FR) 2, HVR2, FR3, and HVR3. In some embodiments, a heavy chain variable region also comprises at least a portion of an FR1 and/or at least a portion of an FR4.

[0048] The term "heavy chain constant region" refers to a region comprising at least three heavy chain constant domains, C_H1, C_H2, and C_H3. Nonlimiting exemplary heavy chain constant regions include γ, δ, and α. Nonlimiting exemplary heavy chain constant regions also include ε and μ. Each heavy constant region corresponds to an antibody isotype. For example, an antibody comprising a γ constant region is an IgG antibody, an antibody comprising a δ constant region is an IgD antibody, and an antibody comprising an α constant region is an IgA antibody. Further, an antibody comprising a μ constant region is an IgM antibody, and an antibody comprising an ε constant region is an IgE antibody. Certain isotypes can be further subdivided into subclasses. For example, IgG antibodies include, but are not limited to, IgG1 (comprising a γ_1 constant region), IgG2 (comprising a γ_2 constant region), IgG3 (comprising a γ_3 constant region), and IgG4 (comprising a γ_4 constant region) antibodies; IgA antibodies include, but are not limited to, IgA1 (comprising an α_1 constant region) and IgA2 (comprising an α_2 constant region) antibodies; and IgM antibodies include, but are not limited to, IgM1 and IgM2.

[0049] The term "heavy chain" refers to a polypeptide comprising at least a heavy chain variable region, with or without a leader sequence. In some embodiments, a heavy chain comprises at least a portion of a heavy chain constant region. The term "full-length heavy chain" refers to a polypeptide comprising a heavy chain variable region and a heavy chain constant region, with or without a leader sequence.

[0050] The term "light chain variable region" refers to a region comprising light chain HVR1, framework (FR) 2, HVR2, FR3, and HVR3. In some embodiments, a light chain variable region also comprises an FR1 and/or an FR4.

[0051] The term "light chain constant region" refers to a region comprising a light chain constant domain, C_L. Nonlimiting exemplary light chain constant regions include λ and κ.

[0052] The term "light chain" refers to a polypeptide comprising at least a light chain variable region, with or without a leader sequence. In some embodiments, a light chain comprises at least a portion of a light chain constant region. The term "full-length light chain" refers to a polypeptide comprising a light chain variable region and a light chain constant region, with or without a leader sequence.

[0053] The term "hypervariable region" or "HVR" refers to each of the regions of an antibody variable domain which are hypervariable in sequence and/or form structurally defined loops ("hypervariable loops"). Generally, native four-chain antibodies comprise six HVRs; three in the V_H (H1, H2, H3), and three in the V_L (L1, L2, L3). HVRs generally comprise amino acid residues from the hypervariable loops and/or from the "complementarity determining regions" (CDRs), the latter being of highest sequence variability and/or involved in antigen recognition. Exemplary hypervariable loops occur at amino acid residues 26-32 (L1), 50-52 (L2), 91-96 (L3), 26-32 (H1), 53-55 (H2), and 96-101 (H3). (Chothia and Lesk, *J. Mol. Biol.* 196:901-917 (1987).) Exemplary CDRs (CDR-L1, CDR-L2, CDR-L3, CDR-H1, CDR-H2, and CDR-H3) occur at amino acid residues 24-34 of L1, 50-56 of L2, 89-97 of L3, 31-35B of H1, 50-65 of H2, and 95-102 of H3. (Kabat *et al.*, Sequences of Proteins of Immunological Interest, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, MD (1991)). The terms hypervariable regions (HVRs) and complementarity determining regions (CDRs), are used herein interchangeably in reference to portions of the variable region that form the antigen binding regions.

[0054] An "acceptor human framework" for the purposes herein is a framework comprising the amino acid sequence of a light chain variable domain (V_L) framework or a heavy chain variable domain (V_H) framework derived from a human immunoglobulin framework or a human consensus framework, as defined below. An acceptor human framework derived from a human immunoglobulin framework or a human consensus framework may comprise the same amino acid sequence thereof, or it may contain amino acid sequence changes. In some embodiments, the number of amino acid changes are 10 or less, 9 or less, 8 or less, 7 or less, 6 or less, 5 or less, 4 or less, 3 or less, or 2 or less. In some embodiments, the V_L acceptor human framework is identical in sequence to the V_L human immunoglobulin framework sequence or human consensus framework sequence.

[0055] "Affinity" refers to the strength of the sum total of noncovalent interactions between a single binding site of a molecule (*e.g.*, an antibody) and its binding partner (*e.g.*, an antigen). In some embodiments, "binding affinity" refers to intrinsic binding affinity which reflects a 1:1 interaction between members of a binding pair (*e.g.*, antibody and antigen). The affinity of a

molecule X for its partner Y can generally be represented by the dissociation constant (K_d). Affinity can be measured by common methods known in the art, including those described herein.

[0056] An "affinity matured" antibody refers to an antibody with one or more alterations in one or more hypervariable regions (HVRs) and/or complementarity determining regions (CDRs), compared to a parent antibody which does not possess such alterations, such alterations resulting in an improvement in the affinity of the antibody for antigen.

[0057] A "chimeric antibody" refers to an antibody in which a portion of the heavy and/or light chain is derived from a particular source or species, while the remainder of the heavy and/or light chain is derived from a different source or species. In some embodiments, a chimeric antibody refers to an antibody comprising at least one variable region from a first species (such as mouse, rat, cynomolgus monkey, *etc.*) and at least one constant region from a second species (such as human, cynomolgus monkey, *etc.*). In some embodiments, a chimeric antibody comprises at least one mouse variable region and at least one human constant region. In some embodiments, a chimeric antibody comprises at least one cynomolgus variable region and at least one human constant region. In some embodiments, all of the variable regions of a chimeric antibody are from a first species and all of the constant regions of the chimeric antibody are from a second species.

[0058] A "humanized antibody" refers to an antibody in which at least one amino acid in a framework region of a non-human variable region has been replaced with the corresponding amino acid from a human variable region. In some embodiments, a humanized antibody comprises at least one human constant region or fragment thereof. In some embodiments, a humanized antibody is an Fab, an scFv, a $(Fab')_2$, *etc.*

[0059] An "HVR-grafted antibody" refers to a humanized antibody in which one or more hypervariable regions (HVRs) of a first (non-human) species have been grafted onto the framework regions (FRs) of a second (human) species.

[0060] A "functional Fc region" possesses an "effector function" of a native sequence Fc region. Exemplary "effector functions" include Fc receptor binding; C1q binding; CDC; ADCC; phagocytosis; down regulation of cell surface receptors (*e.g.* B cell receptor; BCR), *etc.* Such effector functions generally require the Fc region to be combined with a binding domain (*e.g.*, an antibody variable domain) and can be assessed using various assays.

[0061] A "native sequence Fc region" comprises an amino acid sequence identical to the amino acid sequence of an Fc region found in nature. Native sequence human Fc regions include a native sequence human IgG1 Fc region (non-A and A allotypes); native sequence human IgG2

Fc region; native sequence human IgG3 Fc region; and native sequence human IgG4 Fc region as well as naturally occurring variants thereof.

[0062] A "variant Fc region" comprises an amino acid sequence which differs from that of a native sequence Fc region by virtue of at least one amino acid modification.

[0063] "Fc receptor" or "FcR" describes a receptor that binds to the Fc region of an antibody. In some embodiments, an FcγR is a native human FcR. In some embodiments, an FcR is one which binds an IgG antibody (a gamma receptor) and includes receptors of the FcγRI, FcγRII, and FcγRIII subclasses, including allelic variants and alternatively spliced forms of those receptors. FcγRII receptors include FcγRIIA (an "activating receptor") and FcγRIIB (an "inhibiting receptor"), which have similar amino acid sequences that differ primarily in the cytoplasmic domains thereof. Activating receptor FcγRIIA contains an immunoreceptor tyrosine-based activation motif (ITAM) in its cytoplasmic domain Inhibiting receptor FcγRIIB contains an immunoreceptor tyrosine-based inhibition motif (ITIM) in its cytoplasmic domain. (see, *e.g.*, Daeron, *Annu. Rev. Immunol.* 15:203-234 (1997)). FcRs are reviewed, for example, in Ravetch and Kinet, *Annu. Rev. Immunol* 9:457-92 (1991); Capel *et al.*, *Immunomethods* 4:25-34 (1994); and de Haas *et al.*, *J. Lab. Clin. Med.* 126:330-41 (1995). Other FcRs, including those to be identified in the future, are encompassed by the term "FcR" herein.

[0064] The term "Fc receptor" or "FcR" also includes the neonatal receptor, FcRn, which is responsible for the transfer of maternal IgGs to the fetus (Guyer *et al.*, *J. Immunol.* 117:587 (1976) and Kim *et al.*, *J. Immunol.* 24:249 (1994)) and regulation of homeostasis of immunoglobulins. Methods of measuring binding to FcRn are known (see, *e.g.*, Ghetie and Ward., *Immunol. Today* 18(12):592-598 (1997); Ghetie *et al.*, *Nature Biotechnology*, 15(7):637-640 (1997); Hinton *et al.*, *J. Biol. Chem.* 279(8):6213-6216 (2004); WO 2004/92219 (Hinton *et al.*).

[0065] "Effector functions" refer to biological activities attributable to the Fc region of an antibody, which vary with the antibody isotype. Examples of antibody effector functions include: Clq binding and complement dependent cytotoxicity (CDC); Fc receptor binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (*e.g.* B cell receptor); and B cell activation.

[0066] "Human effector cells" are leukocytes which express one or more FcRs and perform effector functions. In certain embodiments, the cells express at least FcγRIII and perform ADCC effector function(s). Examples of human leukocytes which mediate ADCC include peripheral blood mononuclear cells (PBMC), natural killer (NK) cells, monocytes, macrophages, cytotoxic

T cells, and neutrophils. The effector cells may be isolated from a native source, *e.g.*, from blood.

[0067] "Antibody-dependent cell-mediated cytotoxicity" or "ADCC" refers to a form of cytotoxicity in which secreted Ig bound onto Fc receptors (FcRs) present on certain cytotoxic cells (*e.g.* NK cells, neutrophils, and macrophages) enable these cytotoxic effector cells to bind specifically to an antigen-bearing target cell and subsequently kill the target cell with cytotoxins. The primary cells for mediating ADCC, NK cells, express FcγRIII only, whereas monocytes express FcγRI, FcγRII, and FcγRIII. FcR expression on hematopoietic cells is summarized in Table 3 on page 464 of Ravetch and Kinet, *Annu. Rev. Immunol* 9:457-92 (1991). To assess ADCC activity of a molecule of interest, an *in vitro* ADCC assay, such as that described in US Pat. Nos. 5,500,362 or 5,821,337 or U.S. Pat. No. 6,737,056 (Presta), may be performed. Useful effector cells for such assays include PBMC and NK cells. Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed *in vivo*, *e.g.*, in an animal model such as that disclosed in Clynes *et al. Proc. Natl. Acad. Sci. (USA)* 95:652-656 (1998). Additional antibodies with altered Fc region amino acid sequences and increased or decreased ADCC activity are described, *e.g.*, in U.S. Pat. No. 7,923,538, and U.S. Pat. No. 7,994,290.

[0068] An antibody having an "enhanced ADCC activity" refers to an antibody that is more effective at mediating ADCC *in vitro* or *in vivo* compared to the parent antibody, wherein the antibody and the parent antibody differ in at least one structural aspect, and when the amounts of such antibody and parent antibody used in the assay are essentially the same. In some embodiments, the antibody and the parent antibody have the same amino acid sequence, but the antibody is afucosylated while the parent antibody is fucosylated. In some embodiments, ADCC activity will be determined using the *in vitro* ADCC assay as herein disclosed, but other assays or methods for determining ADCC activity, *e.g.* in an animal model *etc.*, are contemplated. In some embodiments, an antibody with enhanced ADCC activity has enhanced affinity for Fc gamma RIIIA. In some embodiments, an antibody with enhanced ADCC activity has enhanced affinity for Fc gamma RIIIA (V158). In some embodiments, an antibody with enhanced ADCC activity has enhanced affinity for Fc gamma RIIIA (F158).

[0069] An antibody with "altered" FcR binding affinity or ADCC activity is one which has either enhanced or diminished FcR binding activity and/or ADCC activity compared to a parent antibody, wherein the antibody and the parent antibody differ in at least one structural aspect. An antibody that "displays increased binding" to an FcR binds at least one FcR with better affinity than the parent antibody. An antibody that "displays decreased binding" to an FcR, binds at least one FcR with lower affinity than a parent antibody. Such antibodies that display

decreased binding to an FcR may possess little or no appreciable binding to an FcR, *e.g.*, 0-20% binding to the FcR compared to a native sequence IgG Fc region.

[0070] "Enhanced affinity for Fc gamma RIIIA" refers to an antibody that has greater affinity for Fc gamma RIIIA (also referred to, in some instances, as CD16a) than a parent antibody, wherein the antibody and the parent antibody differ in at least one structural aspect. In some embodiments, the antibody and the parent antibody have the same amino acid sequence, but the antibody is afucosylated while the parent antibody is fucosylated. Any suitable method for determining affinity for Fc gamma RIIIA may be used. In some embodiments, affinity for Fc gamma RIIIA is determined by a method described herein. In some embodiments, an antibody with enhanced affinity for Fc gamma RIIIA has enhanced ADCC activity. In some embodiments, an antibody with enhanced affinity for Fc gamma RIIIA has enhanced affinity for Fc gamma RIIIA(V158). In some embodiments, an antibody with enhanced affinity for Fc gamma RIIIA has enhanced affinity for Fc gamma RIIIA(F158).

[0071] "Afucosylated" antibody or an antibody "lacking fucose" refers to an IgG1 or IgG3 isotype antibody that lacks fucose in its constant region glycosylation. Glycosylation of human IgG1 or IgG3 occurs at Asn297 as core fucosylated biantennary complex oligosaccharide glycosylation terminated with up to 2 Gal residues. In some embodiments, an afucosylated antibody lacks fucose at Asn297. These structures are designated as G0, G1 (α1,6 or α1,3) or G2 glycan residues, depending on the amount of terminal Gal residues. *See, e.g.*, Raju, T. S., *BioProcess Int.* 1: 44-53 (2003). CHO type glycosylation of antibody Fc is described, *e.g.*, in Routier, F. H., *Glycoconjugate J.* 14: 201-207 (1997). In some embodiments, at least 85% of a batch of antibodies recombinantly expressed in non glycomodified CHO host cells are fucosylated at Asn297. When referring to a composition comprising a plurality of antibodies, the antibodies are considered to be afucosylated if <5% of the antibodies in the composition comprise fucose at Asn297. Methods of measuring fucose include any methods known in the art, including the methods described herein. In some embodiments, fucose is detected by the method described in Example 1. In some embodiments, fucose is undetectable in a composition comprising a plurality of afucosylated antibodies. In some embodiments, an afucosylated antibody has enhanced ADCC activity. In some embodiments, an afucosylated antibody has enhanced affinity for Fc gamma RIIIA. In some embodiments, an afucosylated antibody has enhanced affinity for Fc gamma RIIIA(V158). In some embodiments, an afucosylated antibody has enhanced affinity for Fc gamma RIIIA(F158).

[0072] "Complement dependent cytotoxicity" or "CDC" refers to the lysis of a target cell in the presence of complement. Activation of the classical complement pathway is initiated by the

binding of the first component of the complement system (C1q) to antibodies (of the appropriate subclass), which are bound to their cognate antigen. To assess complement activation, a CDC assay, *e.g.*, as described in Gazzano-Santoro *et al.*, *J. Immunol. Methods* 202:163 (1996), may be performed. Antibodies with altered Fc region amino acid sequences and increased or decreased C1q binding capability are described, *e.g.*, in U.S. Pat. No. 6,194,551 B1, U.S. Pat. No. 7,923,538, U.S. Pat. No. 7,994,290 and WO 1999/51642. See also, *e.g.*, Idusogie *et al.*, *J. Immunol.* 164: 4178-4184 (2000).

[0073] The term "substantially similar" or "substantially the same," as used herein, denotes a sufficiently high degree of similarity between two or more numeric values such that one of skill in the art would consider the difference between the two or more values to be of little or no biological and/or statistical significance within the context of the biological characteristic measured by said value. In some embodiments the two or more substantially similar values differ by no more than about any one of 5%, 10%, 15%, 20%, 25%, or 50%.

[0074] The phrase "substantially reduced," or "substantially different," as used herein, denotes a sufficiently high degree of difference between two numeric values such that one of skill in the art would consider the difference between the two values to be of statistical significance within the context of the biological characteristic measured by said values. In some embodiments, the two substantially different numeric values differ by greater than about any one of 10%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 60%, 70%, 80%, 90%, or 100%.

[0075] The terms "leader sequence" and "signal sequence" are used interchangeably to refer to a sequence of amino acid residues located at the N terminus of a polypeptide that facilitates secretion of a polypeptide from a mammalian cell. A leader sequence may be cleaved upon export of the polypeptide from the mammalian cell, forming a mature protein. Leader sequences may be natural or synthetic, and they may be heterologous or homologous to the protein to which they are attached.

[0076] A "native sequence" polypeptide comprises a polypeptide having the same amino acid sequence as a polypeptide found in nature. Thus, a native sequence polypeptide can have the amino acid sequence of naturally occurring polypeptide from any mammal. Such native sequence polypeptide can be isolated from nature or can be produced by recombinant or synthetic means. The term "native sequence" polypeptide specifically encompasses naturally occurring truncated or secreted forms of the polypeptide (*e.g.*, an extracellular domain sequence), naturally occurring variant forms (*e.g.*, alternatively spliced forms) and naturally occurring allelic variants of the polypeptide.

[0077] A polypeptide "variant" means a biologically active polypeptide having at least about 80% amino acid sequence identity with the native sequence polypeptide after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Such variants include, for instance, polypeptides wherein one or more amino acid residues are added, or deleted, at the N- or C-terminus of the polypeptide. In some embodiments, a variant will have at least about 80% amino acid sequence identity. In some embodiment, a variant will have at least about 90% amino acid sequence identity. n some embodiment, a variant will have at least about 95% amino acid sequence identity with the native sequence polypeptide.

[0078] As used herein, "Percent (%) amino acid sequence identity" and "homology" with respect to a peptide, polypeptide or antibody sequence are defined as the percentage of amino acid residues in a candidate sequence that are identical with the amino acid residues in the specific peptide or polypeptide sequence, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity, and not considering any conservative substitutions as part of the sequence identity. Alignment for purposes of determining percent amino acid sequence identity can be achieved in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST, BLAST-2, ALIGN or MEGALIGNTM (DNASTAR) software. Those skilled in the art can determine appropriate parameters for measuring alignment, including any algorithms needed to achieve maximal alignment over the full length of the sequences being compared.

[0079] An amino acid substitution may include but are not limited to the replacement of one amino acid in a polypeptide with another amino acid. Conservative substitutions are shown in Table 1 under the heading of "preferred substitutions". More substantial changes are provided in Table 1 under the heading of "exemplary substitutions", and as further described below in reference to amino acid side chain classes. Amino acid substitutions may be introduced into an antibody of interest and the products screened for a desired activity, *e.g.*, retained/improved antigen binding, decreased immunogenicity, or improved ADCC or CDC.

TABLE 1

Original Residue	Exemplary Substitutions	Preferred Substitutions
Ala (A)	Val; Leu; Ile	Val
Arg (R)	Lys; Gln; Asn	Lys
Asn (N)	Gln; His; Asp, Lys; Arg	Gln
Asp (D)	Glu; Asn	Glu
Cys (C)	Ser; Ala	Ser
Gln (Q)	Asn; Glu	Asn
Glu (E)	Asp; Gln	Asp
Gly (G)	Ala	Ala
His (H)	Asn; Gln; Lys; Arg	Arg
Ile (I)	Leu; Val; Met; Ala; Phe; Norleucine	Leu
Leu (L)	Norleucine; Ile; Val; Met; Ala; Phe	Ile
Lys (K)	Arg; Gln; Asn	Arg
Met (M)	Leu; Phe; Ile	Leu
Phe (F)	Trp; Leu; Val; Ile; Ala; Tyr	Tyr
Pro (P)	Ala	Ala
Ser (S)	Thr	Thr
Thr (T)	Val; Ser	Ser
Trp (W)	Tyr; Phe	Tyr
Tyr (Y)	Trp; Phe; Thr; Ser	Phe
Val (V)	Ile; Leu; Met; Phe; Ala; Norleucine	Leu

[0080] Amino acids may be grouped according to common side-chain properties:

(1) hydrophobic: Norleucine, Met, Ala, Val, Leu, Ile;

(2) neutral hydrophilic: Cys, Ser, Thr, Asn, Gln;

(3) acidic: Asp, Glu;

(4) basic: His, Lys, Arg;

(5) residues that influence chain orientation: Gly, Pro;

(6) aromatic: Trp, Tyr, Phe.

[0081] Non-conservative substitutions will entail exchanging a member of one of these classes for another class.

[0082] The term "vector" is used to describe a polynucleotide that may be engineered to contain a cloned polynucleotide or polynucleotides that may be propagated in a host cell. A vector may

include one or more of the following elements: an origin of replication, one or more regulatory sequences (such as, for example, promoters and/or enhancers) that regulate the expression of the polypeptide of interest, and/or one or more selectable marker genes (such as, for example, antibiotic resistance genes and genes that may be used in colorimetric assays, *e.g.*, β-galactosidase). The term "expression vector" refers to a vector that is used to express a polypeptide of interest in a host cell.

[0083] A "host cell" refers to a cell that may be or has been a recipient of a vector or isolated polynucleotide. Host cells may be prokaryotic cells or eukaryotic cells. Exemplary eukaryotic cells include mammalian cells, such as primate or non-primate animal cells; fungal cells, such as yeast; plant cells; and insect cells. Nonlimiting exemplary mammalian cells include, but are not limited to, NSO cells, PER.C6® cells (Crucell), and 293 and CHO cells, and their derivatives, such as 293-6E and DG44 cells, respectively.

[0084] The term "isolated" refers to a molecule that has been separated from at least some of the components with which it is typically found in nature or produced. For example, a polypeptide is referred to as "isolated" when it is separated from at least some of the components of the cell in which it was produced. Where a polypeptide is secreted by a cell after expression, physically separating the supernatant containing the polypeptide from the cell that produced it is considered to be "isolating" the polypeptide. Similarly, a polynucleotide is referred to as "isolated" when it is not part of the larger polynucleotide (such as, for example, genomic DNA or mitochondrial DNA, in the case of a DNA polynucleotide) in which it is typically found in nature, or is separated from at least some of the components of the cell in which it was produced, *e.g.*, in the case of an RNA polynucleotide. Thus, a DNA polynucleotide that is contained in a vector inside a host cell may be referred to as "isolated".

[0085] The terms "individual" or "subject" are used interchangeably herein to refer to an animal; for example a mammal. In some embodiments, methods of treating mammals, including, but not limited to, humans, rodents, simians, felines, canines, equines, bovines, porcines, ovines, caprines, mammalian laboratory animals, mammalian farm animals, mammalian sport animals, and mammalian pets, are provided. In some examples, an "individual" or "subject" refers to an individual or subject in need of treatment for a disease or disorder.

[0086] A "disease" or "disorder" refers to a condition where treatment is needed.

[0087] The term "cancer" refers to a malignant proliferative disorder associated with uncontrolled cell proliferation, unrestrained cell growth, and decreased cell death via apoptosis. Nonlimiting exemplary cancers include gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, and esophageal cancer. In some embodiments, a cancer

comprises an FGFR2 gene amplification. In some embodiments, FGFR2 amplification comprises FGFR2:CEN10 (chromosome 10 centromere) ratio of >3. In some embodiments, a cancer comprising an FGFR2 gene amplification overexpresses FGFR2IIIb. In some embodiments, a cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some embodiments, a cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some embodiments, the expression levels are normalized to GUSB. In some embodiments, a cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some embodiments, a gastric cancer comprises an FGFR2 gene amplification. In some embodiments, a gastric cancer comprising an FGFR2 gene amplification overexpresses FGFR2IIIb. In some embodiments, a gastric cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some embodiments, a gastric cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some embodiments, the expression levels are normalized to GUSB. In some embodiments, a gastric cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some embodiments, overexpression is mRNA overexpression. In some embodiments, overexpression is protein overexpression.

[0088] The term "tumor" is used herein to refer to a group of cells that exhibit abnormally high levels of proliferation and growth. A tumor may be benign, pre-malignant, or malignant; malignant tumor cells are cancerous. Tumor cells may be solid tumor cells or leukemic tumor cells. The term "tumor growth" is used herein to refer to proliferation or growth by a cell or cells that comprise a tumor that leads to a corresponding increase in the size of the tumor.

[0089] As used herein, "treatment" is an approach for obtaining beneficial or desired clinical results. "Treatment" as used herein, covers any administration or application of a therapeutic for disease in a mammal, including a human. For purposes of this invention, beneficial or desired clinical results include, but are not limited to, any one or more of: alleviation of one or more symptoms, diminishment of extent of disease, preventing or delaying spread (*e.g.*, metastasis, for example metastasis to the lung or to the lymph node) of disease, preventing or delaying recurrence of disease, delay or slowing of disease progression, amelioration of the disease state, inhibiting the disease or progression of the disease, inhibiting or slowing the disease or its progression, arresting its development, and remission (whether partial or total). Also encompassed by "treatment" is a reduction of pathological consequence of a proliferative

disease. The methods of the invention contemplate any one or more of these aspects of treatment.

[0090] In the context of cancer, the term "treating" includes any or all of: inhibiting growth of tumor cells or cancer cells, inhibiting replication of tumor cells or cancer cells, lessening of overall tumor burden and ameliorating one or more symptoms associated with the disease.

[0091] The terms "inhibition" or "inhibit" refer to a decrease or cessation of any phenotypic characteristic or to the decrease or cessation in the incidence, degree, or likelihood of that characteristic. To "reduce" or "inhibit" is to decrease, reduce or arrest an activity, function, and/or amount as compared to a reference. In certain embodiments, by "reduce" or "inhibit" is meant the ability to cause an overall decrease of 20% or greater. In another embodiment, by "reduce" or "inhibit" is meant the ability to cause an overall decrease of 50% or greater. In yet another embodiment, by "reduce" or "inhibit" is meant the ability to cause an overall decrease of 75%, 85%, 90%, 95%, or greater.

[0092] A "reference" as used herein, refers to any sample, standard, or level that is used for comparison purposes. A reference may be obtained from a healthy and/or non-diseased sample. In some examples, a reference may be obtained from an untreated sample. In some examples, a reference is obtained from a non-diseased on non-treated sample of a subject individual. In some examples, a reference is obtained from one or more healthy individuals who are not the subject or patient.

[0093] As used herein, "delaying development of a disease" means to defer, hinder, slow, retard, stabilize, suppress and/or postpone development of the disease (such as cancer). This delay can be of varying lengths of time, depending on the history of the disease and/or individual being treated. As is evident to one skilled in the art, a sufficient or significant delay can, in effect, encompass prevention, in that the individual does not develop the disease. For example, a late stage cancer, such as development of metastasis, may be delayed.

[0094] "Preventing," as used herein, includes providing prophylaxis with respect to the occurrence or recurrence of a disease in a subject that may be predisposed to the disease but has not yet been diagnosed with the disease.

[0095] As used herein, to "suppress" a function or activity is to reduce the function or activity when compared to otherwise same conditions except for a condition or parameter of interest, or alternatively, as compared to another condition. For example, an antibody which suppresses tumor growth reduces the rate of growth of the tumor compared to the rate of growth of the tumor in the absence of the antibody.

[0096] An "effective amount" of an agent refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic or prophylactic result.

[0097] A "therapeutically effective amount" of a substance/molecule of the invention, agonist or antagonist may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the substance/molecule, agonist or antagonist to elicit a desired response in the individual. A therapeutically effective amount is also one in which any toxic or detrimental effects of the substance/molecule, agonist or antagonist are outweighed by the therapeutically beneficial effects. A therapeutically effective amount may be delivered in one or more administrations.

[0098] A "prophylactically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired prophylactic result. Typically but not necessarily, 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.

[0099] The terms "pharmaceutical formulation" and "pharmaceutical composition" refer to a preparation which is in such form as to permit the biological activity of the active ingredient(s) to be effective, and which contains no additional components which are unacceptably toxic to a subject to which the formulation would be administered. Such formulations may be sterile.

[0100] A "pharmaceutically acceptable carrier" refers to a non-toxic solid, semisolid, or liquid filler, diluent, encapsulating material, formulation auxiliary, or carrier conventional in the art for use with a therapeutic agent that together comprise a "pharmaceutical composition" for administration to a subject. A pharmaceutically acceptable carrier is non-toxic to recipients at the dosages and concentrations employed and is compatible with other ingredients of the formulation. The pharmaceutically acceptable carrier is appropriate for the formulation employed.

[0101] A "sterile" formulation is aseptic or essentially free from living microorganisms and their spores.

[0102] Administration "in combination with" one or more further therapeutic agents includes simultaneous (concurrent) and consecutive or sequential administration in any order.

[0103] The term "concurrently" is used herein to refer to administration of two or more therapeutic agents, where at least part of the administration overlaps in time or where the administration of one therapeutic agent falls within a short period of time relative to administration of the other therapeutic agent. For example, the two or more therapeutic agents are administered with a time separation of no more than about 60 minutes, such as no more than about any of 30, 15, 10, 5, or 1 minutes.

[0104] The term "sequentially" is used herein to refer to administration of two or more therapeutic agents where the administration of one or more agent(s) continues after discontinuing the administration of one or more other agent(s). For example, administration of the two or more therapeutic agents are administered with a time separation of more than about 15 minutes, such as about any of 20, 30, 40, 50, or 60 minutes, 1 day, 2 days, 3 days, 1 week, 2 weeks, or 1 month, or longer.

[0105] As used herein, "in conjunction with" refers to administration of one treatment modality in addition to another treatment modality. As such, "in conjunction with" refers to administration of one treatment modality before, during or after administration of the other treatment modality to the individual.

[0106] The term "package insert" is used to refer to instructions customarily included in commercial packages of therapeutic products, that contain information about the indications, usage, dosage, administration, combination therapy, contraindications and/or warnings concerning the use of such therapeutic products.

[0107] An "article of manufacture" is any manufacture (*e.g.*, a package or container) or kit comprising at least one reagent, *e.g.*, a medicament for treatment of a disease or disorder (*e.g.*, cancer), or a probe for specifically detecting a biomarker described herein. In certain embodiments, the manufacture or kit is promoted, distributed, or sold as a unit for performing the methods described herein.

II. Anti-FGFR2IIIb Antibodies

[0108] In some aspects, the invention provides an afucosylated antibody directed against FGFR2IIIb. Afucosylated anti-FGFR2IIIb antibodies include, but are not limited to, humanized antibodies, chimeric antibodies, mouse antibodies, and antibodies comprising the heavy chain and/or light chain HVRs (*e.g.* CDRs) discussed herein. In one aspect, the invention provides isolated afucosylated antibodies that bind to FGFR2IIIb. In certain embodiments, an afucosylated anti-FGFR2IIIb antibody modulates FGFR2IIIb activity. In some embodiments, an afucosylated anti-FGFR2IIIb antibody has enhanced ADCC activity. In some embodiments, an afucosylated anti-FGFR2IIIb antibody has enhanced affinity for Fc gamma RIIIA. In some embodiments, an afucosylated anti-FGFR2IIIb antibody has enhanced affinity for Fc gamma RIIIA(V158). In some embodiments, an afucosylated anti-FGFR2IIIb antibody has enhanced affinity for Fc gamma RIIIA(F158).

[0109] The anti-FGFR2IIIb antibody designated "αFGFR2b" described herein in the Examples and the sequence listing is intended to have the same amino acid sequence as antibody HuGAL-

FR21 in U.S. Patent No. 8,101,723 B2, issued January 24, 2012. U.S. Patent No. 8,101,723 B2 is specifically incorporated herein by reference for any purpose, and in particular, Figures 13 and 14 of U.S. Patent No. 8,101,723 B2, which show the amino acid sequences of the variable regions and full-length mature antibody chains of HuGAL-FR21, are incorporated by reference herein for any purpose. In addition, the HVR sequences of antibody HuGAL-FR21, which are underlined in Figure 13 of U.S. Patent No. 8,101,723 B2, are specifically incorporated by reference herein for any purpose.

[0110] In one aspect, the invention provides an afucosylated anti-FGFR2IIIb antibody comprising at least one, two, three, four, five, or six HVRs (*e.g.*, CDRs) selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0111] In some embodiments, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain variable region and a light chain variable region. In some embodiments, an afucosylated anti-FGFR2IIIb antibody comprises at least one heavy chain comprising a heavy chain variable region and at least a portion of a heavy chain constant region, and at least one light chain comprising a light chain variable region and at least a portion of a light chain constant region. In some embodiments, an afucosylated anti-FGFR2IIIb antibody comprises two heavy chains, wherein each heavy chain comprises a heavy chain variable region and at least a portion of a heavy chain constant region, and two light chains, wherein each light chain comprises a light chain variable region and at least a portion of a light chain constant region. In some embodiments, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 4 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. In some embodiments, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 2 and a light chain comprising the amino acid sequence of SEQ ID NO: 3.

[0112] In one aspect, the invention provides an afucosylated anti-FGFR2IIIb antibody comprising six HVRs comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11. In some

embodiments, the afucosylated anti-FGFR2IIIb antibody comprises the six HVRs as described above and binds to FGFR2IIIb. In some embodiments, the afucosylated anti-FGFR2IIIb antibody comprises the six HVRs as described above, binds to FGFR2IIIb and has at least one activity selected from enhanced ADCC activity and enhanced affinity for Fc gamma RIIIA (such as Fc gamma RIIIA(V158) and/or Fc gamma RIIIA(F158)). In some embodiments, the afucosylated anti-FGFRIIIb antibody does not bind to FGFR2IIIc.

[0113] In one aspect, the invention provides an afucosylated anti-FGFR2IIIb antibody that competes with an anti-FGFR2IIIb antibody comprising six HVRs comprising (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0114] In one aspect, the invention provides an afucosylated antibody comprising at least one, at least two, or all three V_H HVR sequences selected from (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8.

[0115] In another aspect, the invention provides an afucosylated antibody comprising at least one, at least two, or all three V_L HVR sequences selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0116] In another aspect, an afucosylated antibody of the invention comprises (a) a V_H domain comprising at least one, at least two, or all three V_H HVR sequences selected from (i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6, (ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7, and (iii) HVR-H3 comprising an amino acid sequence selected from SEQ ID NO: 8; and (b) a V_L domain comprising at least one, at least two, or all three V_L HVR sequences selected from (i) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9, (ii) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10, and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0117] In another aspect, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain variable domain (V_H) sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 4. In certain embodiments, a V_H sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions

relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 4. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (*i.e.*, in the FRs). Optionally, the afucosylated anti-FGFR2IIIb antibody comprises the V_H sequence in SEQ ID NO: 5, including post-translational modifications of that sequence. In a particular embodiment, the V_H comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8.

[0118] In another aspect, an afucosylated anti-FGFR2IIIb antibody is provided, wherein the antibody comprises a light chain variable domain (V_L) having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 5. In certain embodiments, a V_L sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 5. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (*i.e.*, in the FRs). Optionally, the afucosylated anti-FGFR2IIIb antibody comprises the V_L sequence in SEQ ID NO: 4, including post-translational modifications of that sequence. In a particular embodiment, the V_L comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0119] In another aspect, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain variable domain (V_H) sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 4 and a light chain variable domain (V_L) having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 5. In certain embodiments, a V_H sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions

relative to the reference sequence, and a V_L sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 4. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 5. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (*i.e.*, in the FRs). Optionally, the afucosylated anti-FGFR2IIIb antibody comprises the V_H sequence in SEQ ID NO: 4 and the V_L sequence of SEQ ID NO: 5, including post-translational modifications of one or both sequence. In a particular embodiment, the V_H comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; and the V_L comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0120] In another aspect, an afucosylated anti-FGFR2IIIb antibody is provided, wherein the antibody comprises a V_H as in any of the embodiments provided above, and a V_L as in any of the embodiments provided above. In one embodiment, the antibody comprises the V_H and V_L sequences in SEQ ID NO: 4 and SEQ ID NO: 5, respectively, including post-translational modifications of those sequences.

[0121] In another aspect, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 2. In certain embodiments, a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an afucosylated anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 2. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (i.e., in the FRs). Optionally, the afucosylated anti-FGFR2IIIb

antibody heavy chain comprises the V_H sequence in SEQ ID NO: 2, including post-translational modifications of that sequence. In a particular embodiment, the heavy chain comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8.

[0122] In another aspect, an afucosylated anti-FGFR2IIIb antibody is provided, wherein the antibody comprises a light chain having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 3. In certain embodiments, a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 3. In certain embodiments, the substitutions, insertions, or deletions occur in regions outside the HVRs (*i.e.*, in the FRs). Optionally, the afucosylated anti-FGFR2IIIb antibody light chain comprises the V_L sequence in SEQ ID NO: 3, including post-translational modifications of that sequence. In a particular embodiment, the light chain comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

[0123] In another aspect, an afucosylated anti-FGFR2IIIb antibody comprises a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 2 and a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity to the amino acid sequence of SEQ ID NO: 3. In certain embodiments, a heavy chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a light chain sequence having at least 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identity contains substitutions (*e.g.*, conservative substitutions), insertions, or deletions relative to the reference sequence, but an anti-FGFR2IIIb antibody comprising that sequence retains the

ability to bind to FGFR2IIIb. In certain embodiments, such anti-FGFR2IIIb antibody retains the ability to selectively bind to FGFR2IIIb without binding to FGFR2IIIc. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 2. In certain embodiments, a total of 1 to 10 amino acids have been substituted, inserted and/or deleted in SEQ ID NO: 3. In certain embodiments, substitutions, insertions, or deletions occur in regions outside the HVRs (*i.e.*, in the FRs). Optionally, the afucosylated anti-FGFR2IIIb antibody heavy chain comprises the V_H sequence in SEQ ID NO: 2, including post-translational modifications of that sequence and the afucosylated anti-FGFR2IIIb antibody light chain comprises the V_L sequence in SEQ ID NO: 3, including post-translational modifications of that sequence. In a particular embodiment, the heavy chain comprises one, two or three HVRs selected from: (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; and the light chain comprises one, two or three HVRs selected from (a) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (b) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (c) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11.

Exemplary chimeric antibodies

[0124] In certain embodiments, an antibody, such as an afucosylated antibody, provided herein is a chimeric antibody. Certain chimeric antibodies are described, *e.g.*, in U.S. Patent No. 4,816,567; and Morrison *et al.*, (1984) *Proc. Natl. Acad. Sci. USA*, 81 :6851-6855 (1984)). In one example, a chimeric antibody comprises a non-human variable region (*e.g.*, a variable region derived from a mouse, rat, hamster, rabbit, or non-human primate, such as a monkey) and a human constant region. In a further example, a chimeric antibody is a "class switched" antibody in which the class or subclass has been changed from that of the parent antibody. Chimeric antibodies include antigen-binding fragments thereof.

[0125] Nonlimiting exemplary afucsoylated chimeric antibodies include chimeric antibodies comprising heavy chain HVR1, HVR2, and HVR3, and/or light chain HVR1, HVR2, and HVR3 sequences described herein. In some embodiments, the afucosylated chimeric anti-FGFR2IIIb antibody comprises the variable regions described above and binds to FGFR2IIIb. In some embodiments, the afucosylated chimeric anti-FGFR2IIIb antibody comprises the variable regions described above, binds to FGFR2IIIb and has at least one activity selected from enhanced ADCC activity and enhanced affinity for Fc gamma RIIIA (such as Fc gamma RIIIA(V158) and/or Fc gamma RIIIA(F158)). In some embodiments, the afucosylated chimeric anti-FGFRIIIb antibody does not bind to FGFR2IIIc.

[0126] In some embodiments, an afucosylated chimeric anti-FGFR2IIIb antibody comprises a heavy chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical SEQ ID NO: 4, wherein the antibody binds FGFR2IIIb. In some embodiments, an afucosylated chimeric anti-FGFR2IIIb antibody comprises a light chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 5, wherein the antibody binds FGFR2IIIb. In some embodiments, an afucosylated chimeric anti-FGFR2IIIb antibody comprises a heavy chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 4; and a light chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 5; wherein the antibody binds FGFR2IIIb.

[0127] Exemplary afucosylated chimeric anti-FGFR2IIIb antibodies also include chimeric antibodies that compete for binding to FGFR2IIIb with an antibody or fragment thereof described herein. Thus, in some embodiments, a chimeric anti-FGFR2IIIb antibody is provided that competes for binding to FGFR2IIIb with an antibody comprising a heavy chain variable region comprising the amino acid sequence of SEQ ID NO: 4 and a light chain variable region comprising the amino acid sequence of SEQ ID NO: 5. In some embodiments, the antibody competes for binding to FGFR2IIIb, but does not bind FGFR2IIIc.

[0128] In some embodiments, a chimeric antibody described herein comprises one or more human constant regions. In some embodiments, the human heavy chain constant region is of an isotype selected from IgA, IgG, and IgD. In some embodiments, the human light chain constant region is of an isotype selected from κ and λ. In some embodiments, a chimeric antibody described herein comprises a human IgG constant region. In some embodiments, a chimeric antibody described herein comprises a human IgG4 heavy chain constant region. In some embodiments, a chimeric antibody described herein comprises a human IgG4 constant region and a human κ light chain.

[0129] As noted above, whether or not effector function is desirable may depend on the particular method of treatment intended for an antibody. Thus, in some embodiments, when effector function is desirable, a chimeric anti-FGFR2IIIb antibody comprising a human IgG1 heavy chain constant region or a human IgG3 heavy chain constant region is selected. In some

embodiments, when effector function is not desirable, a chimeric anti-FGFR2IIIb antibody comprising a human IgG4 or IgG2 heavy chain constant region is selected.

Exemplary humanized antibodies

[0130] In some embodiments, afucosylated humanized antibodies that bind FGFR2IIIb are provided. Humanized antibodies are useful as therapeutic molecules because humanized antibodies reduce or eliminate the human immune response to non-human antibodies (such as the human anti-mouse antibody (HAMA) response), which can result in an immune response to an antibody therapeutic, and decreased effectiveness of the therapeutic.

[0131] In certain embodiments, a chimeric antibody is a humanized antibody. Typically, a non-human antibody is humanized to reduce immunogenicity to humans, while retaining the specificity and affinity of the parental non-human antibody. Generally, a humanized antibody comprises one or more variable domains in which HVRs, *e.g.*, CDRs, (or portions thereof) are derived from a non-human antibody, and FRs (or portions thereof) are derived from human antibody sequences. A humanized antibody optionally will also comprise at least a portion of a human constant region. In some embodiments, some FR residues in a humanized antibody are substituted with corresponding residues from a non-human antibody (*e.g.*, the antibody from which the HVR residues are derived), *e.g.*, to restore or improve antibody specificity or affinity.

[0132] Humanized antibodies and methods of making them are reviewed, *e.g.*, in Almagro and Fransson, (2008) *Front. Biosci.* 13: 1619-1633, and are further described, *e.g.*, in Riechmann *et al.*, (1988) *Nature* 332:323-329; Queen *et al.*, (1989) *Proc. Natl Acad. Sci. USA* 86: 10029-10033; US Patent Nos. 5, 821,337, 7,527,791, 6,982,321, and 7,087,409; Kashmiri *et al.*, (2005) *Methods* 36:25-34 (describing SDR (a-CDR) grafting); Padlan, (1991) *Mol. Immunol.* 28:489-498 (describing "resurfacing"); Dall'Acqua *et al.*, (2005) *Methods* 36:43-60 (describing "FR shuffling"); and Osbourn *et al.*, (2005) *Methods* 36:61-68 and Klimka *et al.*, (2000) *Br. J. Cancer*, 83:252-260 (describing the "guided selection" approach to FR shuffling).

[0133] Human framework regions that may be used for humanization include but are not limited to: framework regions selected using the "best-fit" method (see, *e.g.*, Sims *et al.* (1993) *J. Immunol.* 151 :2296); framework regions derived from the consensus sequence of human antibodies of a particular subgroup of light or heavy chain variable regions (see, *e.g.*, Carter *et al.* (1992) *Proc. Natl. Acad. Sci. USA*, 89:4285; and Presta *et al.* (1993) *J. Immunol*, 151:2623); human mature (somatically mutated) framework regions or human germline framework regions (see, *e.g.*, Almagro and Fransson, (2008) *Front. Biosci.* 13:1619-1633); and framework regions derived from screening FR libraries (see, *e.g.*, Baca *et al.*, (1997) *J. Biol. Chem.* 272: 10678-10684 and Rosok *et al.*, (1996) *J. Biol. Chem.* 271 :22611-22618).

[0134] Nonlimiting exemplary humanized antibodies include αFGFR2b, described herein. Nonlimiting exemplary afucosylated humanized antibodies include αFGFR2bA, described herein, which has the same amino acid sequences as αFGFR2b comprising fucose (also referred to as αFGFR2bF). Nonlimiting exemplary afucosylated humanized antibodies also include antibodies comprising a heavy chain variable region of αFGFR2b and/or a light chain variable region of αFGFR2b. Nonlimiting exemplary afucosylated humanized antibodies include antibodies comprising a heavy chain variable region of SEQ ID NO: 4 and/or a light chain variable region of SEQ ID NO: 5. Exemplary humanized antibodies also include, but are not limited to, humanized antibodies comprising heavy chain HVR1, HVR2, and HVR3, and/or light chain HVR1, HVR2, and HVR3 of αFGFR2b. In some embodiments, the humanized anti-FGFR2IIIb antibody comprises the HVRs described above (i.e., (a) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6; (b) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; (c) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8; (d) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9; (e) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and (f) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11) and binds to FGFR2IIIb. In some embodiments, the humanized anti-FGFR2IIIb antibody comprises the HVRs described above, binds to FGFR2IIIb and has at least one activity selected from enhanced ADCC activity and enhanced affinity for Fc gamma RIIIA (such as Fc gamma RIIIA(V158) and/or Fc gamma RIIIA(F158)). In some embodiments, the afucosylated humanized anti-FGFRIIIb antibody does not bind to FGFR2IIIc.

[0135] In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises heavy chain HVR1, HVR2, and HVR3 and/or a light chain HVR1, HVR2, and HVR3 of αFGFR2b. Nonlimiting exemplary afucosylated humanized anti-FGFR2IIIb antibodies include antibodies comprising sets of heavy chain HVR1, HVR2, and HVR3 set forth in SEQ ID NOs: 6, 7, and 8. Nonlimiting exemplary afucosylated humanized anti-FGFR2IIIb antibodies also include antibodies comprising sets of light chain HVR1, HVR2, and HVR3 set forth in SEQ ID NOs: 9, 10, and 11.

[0136] In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises a heavy chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 4, and wherein the antibody binds FGFR2IIIb. In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises a light chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99%

identical to SEQ ID NO: 5, wherein the antibody binds FGFR2IIIb. In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises a heavy chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 4; and a light chain comprising a variable region sequence that is at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identical to SEQ ID NO: 5; wherein the antibody binds FGFR2IIIb.

[0137] In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises at least one of the HVRs discussed herein. That is, in some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises at least one HVR selected from a heavy chain HVR1 discussed herein, a heavy chain HVR2 discussed herein, a heavy chain HVR3 discussed herein, a light chain HVR1 discussed herein, a light chain HVR2 discussed herein, and a light chain HVR3 discussed herein. Further, in some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises at least one mutated HVR based on a HVR discussed herein, wherein the mutated HVR comprises 1, 2, 3, or 4 amino acid substitutions relative to the HVR discussed herein. In some embodiments, one or more of the amino acid substitutions are conservative amino acid substitutions. One skilled in the art can select one or more suitable conservative amino acid substitutions for a particular HVR sequence, wherein the suitable conservative amino acid substitutions are not predicted to significantly alter the binding properties of the antibody comprising the mutated HVR.

[0138] Exemplary afucosylated humanized anti-FGFR2IIIb antibodies also include antibodies that compete for binding to FGFR2IIIb with an antibody or fragment thereof described herein. Thus, in some embodiments, a humanized anti-FGFR2IIIb antibody is provided that competes for binding to FGFR2IIIb with αFGFR2b. In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody is provided that competes for binding to FGFR2IIIb with αFGFR2b and has at least one activity selected from enhanced ADCC activity and enhanced affinity for Fc gamma RIIIA (such as Fc gamma RIIIA(V158) and/or Fc gamma RIIIA(F158)). In some embodiments, the afucosylated humanized anti-FGFRIIIb antibody does not bind to FGFR2IIIc.

[0139] In some embodiments, an afucosylated humanized anti-FGFR2IIIb antibody comprises one or more human constant regions. In some embodiments, the human heavy chain constant region is of an isotype selected from IgA, IgG, and IgD. In some embodiments, the human light chain constant region is of an isotype selected from κ and λ.

[0140] In some embodiments, an afucosylated humanized antibody described herein comprises a human IgG constant region. In some embodiments, when effector function is desirable, an

afucosylated humanized anti-FGFR2IIIb antibody comprising a human IgG1 heavy chain constant region or a human IgG3 heavy chain constant region is selected. In some embodiments, an afucosylated humanized antibody described herein comprises a human IgG1 constant region. In some embodiments, an afucosylated humanized antibody described herein comprises a human IgG1 constant region, wherein N297 is not fucosylated. In some embodiments, an afucosylated human antibody described herein comprises a human IgG1 constant region and a human κ light chain.

[0141] In some embodiments, an afucosylated humanized antibody comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 2 and a light chain comprising the amino acid sequence of SEQ ID NO: 3. In some embodiments, an afucosylated humanized antibody comprises a heavy chain consisting of the amino acid sequence of SEQ ID NO: 2, and any post-translational modifications, and a light chain consisting the amino acid sequence of SEQ ID NO: 3, and any post-translational modifications.

Exemplary Antibody Constant Regions

[0142] In some embodiments, an afucosylated antibody described herein comprises one or more human constant regions. In some embodiments, the human heavy chain constant region is of an isotype selected from IgA, IgG, and IgD. In some embodiments, the human light chain constant region is of an isotype selected from κ and λ.

[0143] In some embodiments, an afucosylated antibody described herein comprises a human IgG constant region. In some embodiments, when effector function is desirable, an afucosylated anti-FGFR2IIIb antibody comprising a human IgG1 heavy chain constant region or a human IgG3 heavy chain constant region is selected. In some embodiments, an afucosylated antibody described herein comprises a human IgG1 constant region. In some embodiments, an afucosylated antibody described herein comprises a human IgG1 constant region, wherein N297 is not fucosylated. In some embodiments, an afucosylated antibody described herein comprises a human IgG1 constant region and a human κ light chain.

[0144] Throughout the present specification and claims unless explicitly stated or known to one skilled in the art, the numbering of the residues in an immunoglobulin heavy chain is that of the EU index as in Kabat *et al.*, *Sequences of Proteins of Immunological Interest*, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, Md. (1991), expressly incorporated herein by reference. The "EU index as in Kabat" refers to the residue numbering of the human IgG1 EU antibody.

[0145] In certain embodiments, an antibody of the invention comprises a variant Fc region has at least one amino acid substitution compared to the Fc region of a wild-type IgG or a wild-type

antibody. In certain embodiments, the variant Fc region has two or more amino acid substitutions in the Fc region of the wild-type antibody. In certain embodiments, the variant Fc region has three or more amino acid substitutions in the Fc region of the wild-type antibody. In certain embodiments, the variant Fc region has at least one, two or three or more Fc region amino acid substitutions described herein. In certain embodiments, the variant Fc region herein will possess at least about 80% homology with a native sequence Fc region and/or with an Fc region of a parent antibody. In certain embodiments, the variant Fc region herein will possess at least about 90% homology with a native sequence Fc region and/or with an Fc region of a parent antibody. In certain embodiments, the variant Fc region herein will possess at least about 95% homology with a native sequence Fc region and/or with an Fc region of a parent antibody.

[0146] In certain embodiments, an antibody provided herein is altered to increase or decrease the extent to which the antibody is glycosylated. Addition or deletion of glycosylation sites to an antibody may be conveniently accomplished by altering the amino acid sequence such that one or more glycosylation sites is created or removed.

[0147] Where the antibody comprises an Fc region, the carbohydrate attached thereto may be altered. Native antibodies produced by mammalian cells typically comprise a branched, biantennary oligosaccharide that is generally attached by an N-linkage to Asn297 of the CH2 domain of the Fc region. See, *e.g.*, Wright *et al. TIBTECH* 15:26-32 (1997). The oligosaccharide may include various carbohydrates, *e.g.*, mannose, N-acetyl glucosamine (GlcNAc), galactose, and sialic acid, as well as a fucose attached to a GlcNAc in the "stem" of the biantennary oligosaccharide structure. In some embodiments, modifications of the oligosaccharide in an antibody of the invention may be made in order to create antibodies with certain improved properties.

[0148] In one embodiment, antibodies are provided having a carbohydrate structure that lacks fucose attached (directly or indirectly) to an Fc region (i.e., afucosylated antibodies). For example, the amount of fucose in a composition comprising a plurality of such antibodies may be from 0% to about 5%. In some embodiments, a composition comprising a plurality of such antibodies comprises at least 95% afucosylated antibodies. The amount of fucose is determined by calculating the average amount of fucose within the sugar chain at Asn297, relative to the sum of all glycostructures attached to Asn 297 (*e.g.*, complex, hybrid and high mannose structures). Nonlimiting exemplary methods of detecting fucose in an antibody include MALDI-TOF mass spectrometry (*see, e.g.*, WO 2008/077546), HPLC measurement of released fluorescently labeled oligosaccharides (*see, e.g.*, Schneider et al., "N-Glycan analysis of monoclonal antibodies and other glycoproteins using UHPLC with fluorescence detection,"

Agilent Technologies, Inc. (2012); Lines, *J. Pharm. Biomed. Analysis*, 14: 601-608 (1996); Takahasi, *J. Chrom.*, 720: 217-225 (1996)), capillary electrophoresis measurement of released fluorescently labeled oligosaccharides (*see, e.g.*, Ma et al., *Anal. Chem.*, 71: 5185-5192 (1999)), and HPLC with pulsed amperometric detection to measure monosaccharide composition (*see, e.g.*, Hardy, et al., *Analytical Biochem.*, 170: 54-62 (1988)). Asn297 refers to the asparagine residue located at about position 297 in the Fc region (EU numbering of Fc region residues); however, Asn297 may also be located about ± 3 amino acids upstream or downstream of position 297, *i.e.*, between positions 294 and 300, due to minor sequence variations in antibodies. In antibody αFGFR2b described herein, Asn297 is found in the sequence QY**N**ST, and is in bold and underlined in the Table of Sequences shown below, SEQ ID NO: 2. Fucosylation variants may have improved ADCC function. See, *e.g.*, US Patent Publication Nos. US 2003/0157108 (Presta, L.); US 2004/0093621 (Kyowa Hakko Kogyo Co., Ltd). Examples of publications related to "afucosylated" or "fucose-deficient" antibodies include: US 2003/0157108; WO 2000/61739; WO 2001/29246; US 2003/0115614; US 2002/0164328; US 2004/0093621; US 2004/0132140; US 2004/0110704; US 2004/0110282; US 2004/0109865; WO 2003/085119; WO 2003/084570; WO 2005/035586; WO 2005/035778; WO2005/053742; WO2002/031140; Okazaki *et al. J. Mol. Biol.* 336:1239-1249 (2004); Yamane-Ohnuki *et al. Biotech. Bioeng.* 87: 614 (2004). Examples of cell lines capable of producing afucosylated antibodies include Lec13 CHO cells deficient in protein fucosylation (Ripka *et al. Arch. Biochem. Biophys.* 249:533-545 (1986); US Patent Application No. US 2003/0157108 A1, Presta, L; and WO 2004/056312 A1, Adams *et al.*, especially at Example 11), and knockout cell lines, such as cell lines lacking a functional alpha-1,6-fucosyltransferase gene, FUT8, *e.g.*, knockout CHO cells (see, *e.g.*, Yamane-Ohnuki *et al. Biotech. Bioeng.* 87: 614 (2004); Kanda, Y. *et al., Biotechnol. Bioeng.*, 94(4):680-688 (2006); and WO2003/085107).

[0149] Antibodies are further provided with bisected oligosaccharides, *e.g.*, in which a biantennary oligosaccharide attached to the Fc region of the antibody is bisected by GlcNAc. Such antibodies may have reduced fucosylation and/or improved ADCC function. Examples of such antibodies are described, *e.g.*, in WO 2003/011878 (Jean-Mairet *et al.*); US Patent No. 6,602,684 (Umana *et al.*); and US 2005/0123546 (Umana *et al.*). Antibodies with at least one galactose residue in the oligosaccharide attached to the Fc region are also provided. Such antibodies may have improved CDC function. Such antibodies are described, *e.g.*, in WO 1997/30087 (Patel *et al.*); WO 1998/58964 (Raju, S.); and WO 1999/22764 (Raju, S.).

[0150] Antibodies are also provided with amino-terminal leader extensions. For example, one or more amino acid residues of the amino-terminal leader sequence are present at the amino-

terminus of any one or more heavy or light chains of an antibody. An exemplary amino-terminal leader extension comprises or consists of three amino acid residues, VHS, present on one or both light chains of an antibody.

[0151] The *in vivo* or serum half-life of human FcRn high affinity binding polypeptides can be assayed, *e.g.*, in transgenic mice, in humans, or in non-human primates to which the polypeptides with a variant Fc region are administered. See also, *e.g.*, Petkova *et al. International Immunology* 18(12):1759-1769 (2006).

[0152] In some embodiments of the invention, an afucosylated antibody mediates ADCC in the presence of human effector cells more effectively than a parent antibody that comprises fucose, Generally, ADCC activity may be determined using the *in vitro* ADCC assay as herein disclosed, but other assays or methods for determining ADCC activity, *e.g.* in an animal model *etc.*, are contemplated.

[0153] In certain embodiments, the "K_D," "K_d," "Kd" or "Kd value" of the antibody is measured by using surface plasmon resonance assays using a BIACORE®-2000 or a BIACORE®-3000 (BIAcore, Inc., Piscataway, N.J.) at 25 °C with immobilized antigen CM5 chips at ~10 response units (RU). Briefly, carboxymethylated dextran biosensor chips (CM5, BIACORE, Inc.) are activated with N-ethyl-N'-(3-dimethylaminopropyl)-carbodiimide hydrochloride (EDC) and N-hydroxysuccinimide (NHS) according to the supplier's instructions. Antigen is diluted with 10 mM sodium acetate, pH 4.8, to 5 μg/ml (~0.2 μM) before injection at a flow rate of 5 μL/minute to achieve approximately 10 response units (RU) of coupled protein. Following the injection of antigen, 1 M ethanolamine is injected to block unreacted groups. For kinetics measurements, serial dilutions of polypeptide, *e.g.*, full length antibody, are injected in PBS with 0.05% TWEEN-20™ surfactant (PBST) at 25 °C at a flow rate of approximately 25 μL/min. Association rates (k_{on}) and dissociation rates (k_{off}) are calculated using a simple one-to-one Langmuir binding model (BIACORE® Evaluation Software version 3.2) by simultaneously fitting the association and dissociation sensorgrams. The equilibrium dissociation constant (Kd) is calculated as the ratio k_{off}/k_{on}. See, *e.g.*, Chen *et al.*, *J. Mol. Biol.* 293:865-881 (1999). If the on-rate exceeds 10^6 $M^{-1}s^{-1}$ by the surface plasmon resonance assay above, then the on-rate can be determined by using a fluorescent quenching technique that measures the increase or decrease in fluorescence emission intensity (excitation=295 nm; emission=340 nm, 16 nm band-pass) at 25 °C of a 20 nM anti-antigen antibody in PBS, pH 7.2, in the presence of increasing concentrations of antigen as measured in a spectrometer, such as a stop-flow equipped spectrophometer (Aviv Instruments) or a 8000-series SLM-AMINCO™ spectrophotometer (ThermoSpectronic) with a stirred cuvette.

[0154] An "on-rate," "rate of association," "association rate," or "k_{on}" of the antibody can also be determined as described above using a BIACORE®-2000 or a BIACORE®-3000 system (BIAcore, Inc., Piscataway, N.J.).

[0155] In certain embodiments, the difference between said two values (*e.g.*, Kd values) is substantially the same, for example, less than about 50%, less than about 40%, less than about 30%, less than about 20%, and/or less than about 10% as a function of the reference/comparator value.

[0156] In certain embodiments, the difference between said two values (*e.g.*, K_d values) is substantially different, for example, greater than about 10%, greater than about 20%, greater than about 30%, greater than about 40%, and/or greater than about 50% as a function of the value for the reference/comparator molecule.

Exemplary Leader Sequences

[0157] In order for some secreted proteins to express and secrete in large quantities, a leader sequence from a heterologous protein may be desirable. In some embodiments, employing heterologous leader sequences may be advantageous in that a resulting mature polypeptide may remain unaltered as the leader sequence is removed in the ER during the secretion process. The addition of a heterologous leader sequence may be required to express and secrete some proteins.

[0158] Certain exemplary leader sequence sequences are described, *e.g.*, in the online Leader sequence Database maintained by the Department of Biochemistry, National University of Singapore. See Choo *et al.*, *BMC* Bioinformatics, 6: 249 (2005); and PCT Publication No. WO 2006/081430.

III. Properties of Afucosylated Anti-FGFR2IIIb Antibodies

[0159] In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced ADCC activity *in vitro* and/or *in vivo*. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced ADCC activity *in vitro*. In some embodiments, ADCC activity *in vitro* is determined by a method described herein, *e.g.*, in Example 3. Briefly, FGFR2IIIb-expressing cells are contacted with freshly isolated human PBMCs at a ratio of 25:1 effector (PBMCs) to target cells, in the presence of fucosylated antibody or afucosylated antibody. In some embodiments, Ba/F3 cells that express FGFR2IIIb are used as target cells. In some embodiments, cytotoxicity is determined by quantifying LDH release using CytoTox Non-Radioactive Cytotoxicity Assay (Promega, Madison, WI). In some embodiments, maximal lysis is determined using 5% Triton X-100 and spontaneous release is determined in the absence of antibody. In some embodiments, the percentage of specific lysis may be determined using the

formula: (experimental – spontaneous release) / (maximal – spontaneous release) x 100 = % specific lysis. In some embodiments, an afucosylated anti-FGFR2IIIb antibody having enhanced ADCC activity results in specific lysis that is at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 60, at least 65, at least 70, or at least 75 percentage points greater than specific lysis with the same amount of a fucosylated antibody, at at least one concentration of antibody tested. In some embodiments, an afucosylated anti-FGFR2IIIb antibody having enhanced ADCC activity results in specific lysis that is at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 60, at least 65, at least 70, or at least 75 percentage points greater than specific lysis with a fucosylated antibody, where each antibody is at a concentration of between 0.01 and 1 μg/ml and the target cells are Ba/F3 cells expressing FGFR2IIIb. In some embodiments, the antibodies are tested at a concentration of 0.01 μg/ml, 0.1 μg/ml, or 1 μg/ml.

[0160] In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced affinity for Fc gamma RIIIA. In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced affinity for Fc gamma RIIIA(V158). In some embodiments, afucosylated anti-FGFR2IIIb antibodies have enhanced affinity for Fc gamma RIIIA(F158). In some embodiments, antibody affinity for Fc gamma RIIIA is determined using surface plasmon resonance, *e.g.*, as described herein in Example 2, and/or as follows, which is described with reference to Fc gamma RIIIA(V158), but which is also suitable for determining affinity for Fc gamma RIIIA(F158). Briefly, in some embodiments, fucosylated or afucosylated anti-FGFR2IIIb antibody is captured on a protein A-coated dextran chip. Fc gamma RIIIA (V158) (available from, *e.g.*, R&D Systems) is injected at various concentrations. The association constant, dissociation constant, and affinity of Fc gamma RIIIA (V158) for fucosylated and afucosylated anti-FGFR2IIIb antibody may be determined, *e.g.*, using software provided with the surface plasmon resonance system (for example, Biacore T200 Evaluation Software 1:1 binding model). In some embodiments, an afucosylated anti-FGFR2IIIb antibody with enhanced affinity for Fc gamma RIIIA (such as Fc gamma RIIIA(V158) or Fc gamma RIIIA(F158)) binds to Fc gamma RIIIA with at least 2-fold, at least 3-fold, at least 4-fold, at least 5-fold, at least 7-fold, at least 10-fold, at least 12-fold, at least 15-fold, at least 17-fold, or at least 20-fold greater affinity than a fucosylated anti-FGFR2IIIb antibody. For example, if an afucosylated anti-FGFR2IIIb antibody binds to Fc gamma RIIIA (V158) with an affinity (K_D) of 9.2 nM and a fucosylated anti-FGFR2IIIb antibody binds to Fc gamma RIIIA (V158) with an affinity (K_D) of 207 nM, then the afucosylated anti-FGFR2IIIb antibody binds to Fc gamma

RIIIA (V158) with 207/9.2=22.5-fold greater affinity than the fucosylated anti-FGFR2IIIb antibody.

IV. Anti-FGFR2IIIb Antibody Expression and Production

Nucleic Acid Molecules Encoding Anti-FGFR2IIIb Antibodies

[0161] Nucleic acid molecules comprising polynucleotides that encode one or more chains of anti-FGFR2IIIb antibodies are provided. In some embodiments, a nucleic acid molecule comprises a polynucleotide that encodes a heavy chain or a light chain of an anti-FGFR2IIIb antibody. In some embodiments, a nucleic acid molecule comprises both a polynucleotide that encodes a heavy chain and a polynucleotide that encodes a light chain, of an anti-FGFR2IIIb antibody. In some embodiments, a first nucleic acid molecule comprises a first polynucleotide that encodes a heavy chain and a second nucleic acid molecule comprises a second polynucleotide that encodes a light chain.

[0162] In some such embodiments, the heavy chain and the light chain are expressed from one nucleic acid molecule, or from two separate nucleic acid molecules, as two separate polypeptides. In some embodiments, such as when an antibody is an scFv, a single polynucleotide encodes a single polypeptide comprising both a heavy chain and a light chain linked together.

[0163] In some embodiments, a polynucleotide encoding a heavy chain or light chain of an anti-FGFR2IIIb antibody comprises a nucleotide sequence that encodes a leader sequence, which, when translated, is located at the N terminus of the heavy chain or light chain. As discussed above, the leader sequence may be the native heavy or light chain leader sequence, or may be another heterologous leader sequence.

[0164] Nucleic acid molecules may be constructed using recombinant DNA techniques conventional in the art. In some embodiments, a nucleic acid molecule is an expression vector that is suitable for expression in a selected host cell.

Vectors

[0165] Vectors comprising polynucleotides that encode anti-FGFR2IIIb heavy chains and/or anti-FGFR2IIIb light chains are provided. Vectors comprising polynucleotides that encode anti-FGFR2IIIb heavy chains and/or anti-FGFR2IIIb light chains are also provided. Such vectors include, but are not limited to, DNA vectors, phage vectors, viral vectors, retroviral vectors, *etc.* In some embodiments, a vector comprises a first polynucleotide sequence encoding a heavy chain and a second polynucleotide sequence encoding a light chain. In some embodiments, the heavy chain and light chain are expressed from the vector as two separate polypeptides. In some

embodiments, the heavy chain and light chain are expressed as part of a single polypeptide, such as, for example, when the antibody is an scFv.

[0166] In some embodiments, a first vector comprises a polynucleotide that encodes a heavy chain and a second vector comprises a polynucleotide that encodes a light chain. In some embodiments, the first vector and second vector are transfected into host cells in similar amounts (such as similar molar amounts or similar mass amounts). In some embodiments, a mole- or mass-ratio of between 5:1 and 1:5 of the first vector and the second vector is transfected into host cells. In some embodiments, a mass ratio of between 1:1 and 1:5 for the vector encoding the heavy chain and the vector encoding the light chain is used. In some embodiments, a mass ratio of 1:2 for the vector encoding the heavy chain and the vector encoding the light chain is used.

[0167] In some embodiments, a vector is selected that is optimized for expression of polypeptides in CHO or CHO-derived cells, or in NSO cells. Exemplary such vectors are described, *e.g.*, in Running Deer *et al.*, *Biotechnol. Prog.* 20:880-889 (2004).

Host Cells

[0168] In various embodiments, anti-FGFR2IIIb heavy chains and/or anti-FGFR2IIIb light chains may be expressed in prokaryotic cells, such as bacterial cells; or in eukaryotic cells, such as fungal cells (such as yeast), plant cells, insect cells, and mammalian cells. Such expression may be carried out, for example, according to procedures known in the art. Exemplary eukaryotic cells that may be used to express polypeptides include, but are not limited to, COS cells, including COS 7 cells; 293 cells, including 293-6E cells; CHO cells, including CHO-S, DG44. Lec13 CHO cells, and FUT8 CHO cells; PER.C6® cells (Crucell); and NSO cells. In some embodiments, anti-FGFR2IIIb heavy chains and/or anti-FGFR2IIIb light chains may be expressed in yeast. See, *e.g.*, U.S. Publication No. US 2006/0270045 A1. In some embodiments, a particular eukaryotic host cell is selected based on its ability to make desired post-translational modifications to the anti-FGFR2IIIb heavy chains and/or anti-FGFR2IIIb light chains. For example, in some embodiments, CHO cells produce polypeptides that have a higher level of sialylation than the same polypeptide produced in 293 cells.

[0169] Introduction of one or more nucleic acids into a desired host cell may be accomplished by any method, including but not limited to, calcium phosphate transfection, DEAE-dextran mediated transfection, cationic lipid-mediated transfection, electroporation, transduction, infection, *etc.* Nonlimiting exemplary methods are described, *e.g.*, in Sambrook *et al.*, Molecular Cloning, A Laboratory Manual, 3rd ed. Cold Spring Harbor Laboratory Press (2001). Nucleic acids may be transiently or stably transfected in the desired host cells, according to any suitable method.

[0170] In some embodiments afucosylated anti-FGFR2IIIb antibodies are produced in cells capable of producing afucosylated antibodies, such as Lec13 CHO cells deficient in protein fucosylation (Ripka *et al. Arch. Biochem. Biophys.* 249:533-545 (1986); US Patent Application No. US 2003/0157108 A1, Presta, L; and WO 2004/056312 A1, Adams *et al.*, especially at Example 11), and knockout cell lines, such as cell lines lacking a functional alpha-1,6-fucosyltransferase gene, FUT8, *e.g.*, knockout CHO cells (see, *e.g.*, Yamane-Ohnuki *et al. Biotech. Bioeng.* 87: 614 (2004); Kanda, Y. *et al., Biotechnol. Bioeng.*, 94(4):680-688 (2006); and WO2003/085107). In some embodiments, afucosylated anti-FGFR2IIIb antibodies are produced in CHO cells lacking a functional FUT8 gene. In some embodiments, afucosylated anti-FGFR2IIIb antibodies are produced in Potelligent® CHOK1SV cells (BioWa/Lonza, Allendale, NJ).

Purification of Anti-FGFR2IIIb Antibodies

[0171] Anti-FGFR2IIIb antibodies may be purified by any suitable method. Such methods include, but are not limited to, the use of affinity matrices or hydrophobic interaction chromatography. Suitable affinity ligands include the FGFR2IIIb ECD and ligands that bind antibody constant regions. For example, a Protein A, Protein G, Protein A/G, or an antibody affinity column may be used to bind the constant region and to purify an anti-FGFR2IIIb antibody. Hydrophobic interactive chromatography, for example, a butyl or phenyl column, may also suitable for purifying some polypeptides. Many methods of purifying polypeptides are known in the art.

Cell-Free Production of Anti-FGFR2IIIb Antibodies

[0172] In some embodiments, an anti-FGFR2IIIb antibody is produced in a cell-free system. Nonlimiting exemplary cell-free systems are described, *e.g.*, in Sitaraman *et al.*, *Methods Mol. Biol.* 498: 229-44 (2009); Spirin, *Trends Biotechnol.* 22: 538-45 (2004); Endo *et al.*, *Biotechnol. Adv.* 21: 695-713 (2003).

V. Therapeutic Compositions and Methods

Methods of Treating Diseases using anti-FGFR2IIIb Antibodies

[0173] Antibodies of the invention, and compositions comprising antibodies of the invention, are provided for use in methods of treatment for humans or animals. Methods of treating disease comprising administering afucosylated anti-FGFR2IIIb antibodies are also provided. Nonlimiting exemplary diseases that can be treated with afucosylated anti-FGFR2IIIb antibodies include, but are not limited to cancer. In some embodiments, methods of treating cancer are provided, comprising administering an afucosylated anti-FGFR2IIIb antibody. In some embodiments, the cancer is selected from gastric cancer, breast cancer, ovarian cancer,

endometrial cancer, pancreatic cancer, or esophageal cancer. In some embodiments, methods of treating gastric cancer are provided, comprising administering an afucosylated anti-FGFR2IIIb antibody.

[0174] In some embodiments, a cancer comprises an FGFR2 gene amplification. In some embodiments, a cancer comprising an FGFR2 gene amplification overexpresses FGFR2IIIb. In some embodiments, a cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some embodiments, a cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some embodiments, the expression levels are normalized to GUSB. In some embodiments, a cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some embodiments, a gastric cancer comprises an FGFR2 gene amplification. In some embodiments, a gastric cancer comprising an FGFR2 gene amplification overexpresses FGFR2IIIb. In some embodiments, a gastric cancer comprising FGFR2 amplification overexpresses FGFR2IIIb to a greater extent than FGFR2IIIc. In some embodiments, a gastric cancer comprising FGFR2 amplification expresses FGFR2IIIb at a normalized level that is more than 2-fold, 3-fold, 5-fold, or 10-fold greater than the normalized level of FGFR2IIIc expression. In some embodiments, the expression levels are normalized to GUSB. In some embodiments, a gastric cancer overexpresses FGFR2IIIb but does not comprise FGFR2 gene amplification. In some embodiments, overexpression is mRNA overexpression. In some embodiments, overexpression is protein overexpression.

[0175] FGFR2IIIb gene amplification may be determined by any suitable method in the art, including but not limited to, in situ hybridization (ISH). In some embodiments, FGFR2 amplification comprises FGFR2:CEN10 (chromosome 10 centromere) ratio of >3.

[0176] FGFR2IIIb mRNA overexpression may be determined by any suitable method in the art, including but not limited to, methods comprising quantitative PCR (qPCR). The term "FGFR2IIIb mRNA overexpression" means elevated levels of FGFR2IIIb mRNA, regardless of the cause of such elevated levels (i.e., whether the elevated levels are a result of increased transcription and/or decreased degradation of mRNA, other mechanism, or a combination of mechanisms).

[0177] FGFR2IIIb protein overexpression may be determined by any suitable method in the art, including but not limited to, antibody-based methods such as immunohistochemistry (IHC). In some embodiments, the IHC staining is scored according to methods in the art. The term "FGFR2IIIb protein overexpression" means elevated levels of FGFR2IIIb protein, regardless of

the cause of such elevated levels (i.e., whether the elevated levels are a result of increased translation and/or decreased degradation of protein, other mechanism, or a combination of mechanisms). In some embodiments, 1+, 2+, or 3+ staining of tumor cells by IHC indicates FGFR2IIIb overexpression. In some embodiments, 2+ or 3+ staining of tumor cells by IHC indicates FGFR2IIIb overexpression. In some embodiments, the IHC staining is scored as described in Example 6.

Pharmaceutical compositions

[0178] In various embodiments, compositions comprising afucosylated anti-FGFR2IIIb antibodies are provided in formulations with a wide variety of pharmaceutically acceptable carriers (see, *e.g.*, Gennaro, Remington: The Science and Practice of Pharmacy with Facts and Comparisons: Drugfacts Plus, 20th ed. (2003); Ansel *et al.*, Pharmaceutical Dosage Forms and Drug Delivery Systems, 7th ed., Lippencott Williams and Wilkins (2004); Kibbe *et al.*, Handbook of Pharmaceutical Excipients, 3rd ed., Pharmaceutical Press (2000)). Various pharmaceutically acceptable carriers, which include vehicles, adjuvants, and diluents, are available. Moreover, various pharmaceutically acceptable auxiliary substances, such as pH adjusting and buffering agents, tonicity adjusting agents, stabilizers, wetting agents and the like, are also available. Non-limiting exemplary carriers include saline, buffered saline, dextrose, water, glycerol, ethanol, and combinations thereof.

[0179] In various embodiments, compositions comprising afucosylated anti-FGFR2IIIb antibodies may be formulated for injection, including subcutaneous administration, by dissolving, suspending, or emulsifying them in an aqueous or nonaqueous solvent, such as vegetable or other oils, synthetic aliphatic acid glycerides, esters of higher aliphatic acids, or propylene glycol; and if desired, with conventional additives such as solubilizers, isotonic agents, suspending agents, emulsifying agents, stabilizers and preservatives. In various embodiments, the compositions may be formulated for inhalation, for example, using pressurized acceptable propellants such as dichlorodifluoromethane, propane, nitrogen, and the like. The compositions may also be formulated, in various embodiments, into sustained release microcapsules, such as with biodegradable or non-biodegradable polymers. A non-limiting exemplary biodegradable formulation includes poly lactic acid-glycolic acid polymer. A non-limiting exemplary non-biodegradable formulation includes a polyglycerin fatty acid ester. Certain methods of making such formulations are described, for example, in EP 1 125 584 A1.

Routes of Administration

[0180] In various embodiments, afucosylated anti-FGFR2IIIb antibodies may be administered *in vivo* by various routes, including, but not limited to, oral, intra-arterial, parenteral, intranasal,

intramuscular, intracardiac, intraventricular, intratracheal, buccal, rectal, intraperitoneal, intradermal, topical, transdermal, and intrathecal, or otherwise by implantation or inhalation. The subject compositions may be formulated into preparations in solid, semi-solid, liquid, or gaseous forms; including, but not limited to, tablets, capsules, powders, granules, ointments, solutions, suppositories, enemas, injections, inhalants, and aerosols. The appropriate formulation and route of administration may be selected according to the intended application.

[0181] Pharmaceutical compositions are administered in an amount effective for treatment or prophylaxis of cancer, such as gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, or esophageal cancer. The therapeutically effective amount is typically dependent on the weight of the subject being treated, his or her physical or health condition, the extensiveness of the condition to be treated, or the age of the subject being treated. In general, afucosylated anti-FGFR2IIIb antibodies may be administered in an amount in the range of about 10 μg/kg body weight to about 100 mg/kg body weight per dose. In some embodiments, afucosylated anti-FGFR2IIIb antibodies may be administered in an amount in the range of about 50 μg/kg body weight to about 5 mg/kg body weight per dose. In some embodiments, anti-FGFR2IIIb antibodies may be administered in an amount in the range of about 100 μg/kg body weight to about 10 mg/kg body weight per dose. In some embodiments, afucosylated anti-FGFR2IIIb antibodies may be administered in an amount in the range of about 100 μg/kg body weight to about 20 mg/kg body weight per dose. In some embodiments, afucosylated anti-FGFR2IIIb antibodies may be administered in an amount in the range of about 0.5 mg/kg body weight to about 20 mg/kg body weight per dose.

[0182] The afucosylated anti-FGFR2IIIb antibody compositions may be administered as needed to subjects. Determination of the frequency of administration may be made by persons skilled in the art, such as an attending physician based on considerations of the condition being treated, age of the subject being treated, severity of the condition being treated, general state of health of the subject being treated and the like. In some embodiments, an effective dose of an afucosylated anti-FGFR2IIIb antibody is administered to a subject one or more times. In various embodiments, an effective dose of an afucosylated anti-FGFR2IIIb antibody is administered to the subject once a month, more than once a month, such as, for example, every two months or every three months. In other embodiments, an effective dose of an afucosylated anti-FGFR2IIIb antibody is administered less than once a month, such as, for example, every two weeks or every week. An effective dose of an afucosylated anti-FGFR2IIIb antibody is administered to the subject at least once. In some embodiments, the effective dose of an afucosylated anti-

FGFR2IIIb antibody may be administered multiple times, including for periods of at least a month, at least six months, or at least a year.

Combination Therapy

[0183] Afucosylated anti-FGFR2IIIb antibodies may be administered alone or with other modes of treatment. They may be provided before, substantially contemporaneous with, or after other modes of treatment, for example, surgery, chemotherapy, or radiation therapy. In some embodiments, an afucosylated anti-FGFR2IIIb antibody is administered in conjunction with another anti-cancer agent. Nonlimiting exemplary anti-cancer agents that may be administered with an afucosylated anti-FGFR2IIIb antibody include platinum agents (such as cisplatin, oxaliplatin, and carboplatin), paclitaxel (TAXOL®), albumin-engineered nanoparticle formulation of paclitaxel (ABRAXANE®), docetaxel (TAXOTERE®), gemcitabine (GEMZAR®), capecitabine (XELODA®), irinotecan (CAMPTOSAR®), epirubicin (ELLENCE®, PHARMORUBICIN®), FOLFOX (oxaliplatin combined with 5-FU and leucovorin), FOLFIRI (combination of leucovorin, 5-FU and irinotecan), leucovorin, fluorouracil (5-FU, EFUDEX®), mitomycin C (MITOZYTREX™, MUTAMYCIN®), and doxorubicin hydrochloride (Adriamycin PFS, Adriamycin RDF, RUBEX®). In some embodiments, an afucosylated anti-FGFR2IIIb antibody is administered in conjunction with paclitaxel. In some embodiments, an afucosylated anti-FGFR2IIIb antibody is administered in conjunction with cisplatin and/or 5-FU. In some embodiments, an afucosylated anti-FGFR2IIIb antibody is administered in conjunction with cisplatin and 5-FU. In some embodiments, an afucosylated anti-FGFR2IIIb antibody is administered in conjunction with FOLFOX (oxaliplatin, 5-FU, and leucovorin).

Kits/Articles of Manufacture

[0184] The invention also provides kits, medicines, compositions, and unit dosage forms for use in any of the methods described herein.

[0185] Kits of the invention include one or more containers comprising an afucosylated anti-FGFR2IIIb antibody (or unit dosage forms and/or articles of manufacture). In some embodiments, a unit dosage is provided wherein the unit dosage contains a predetermined amount of a composition comprising an afucosylated anti-FGFR2IIIb antibody, with or without one or more additional agents. In some embodiments, such a unit dosage is supplied in single-use prefilled syringe for injection. In various embodiments, the composition contained in the unit dosage may comprise saline, sucrose, or the like; a buffer, such as phosphate, or the like; and/or be formulated within a stable and effective pH range. Alternatively, in some embodiments, the composition may be provided as a lyophilized powder that may be

reconstituted upon addition of an appropriate liquid, for example, sterile water. In some embodiments, the composition comprises one or more substances that inhibit protein aggregation, including, but not limited to, sucrose and arginine. In some embodiments, a composition of the invention comprises heparin and/or a proteoglycan.

[0186] In some embodiments, kits of the invention further comprise instructions for use in the treatment of, *e.g.*, cancer (such as gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, or esophageal cancer) in accordance with any of the methods described herein. The kit may further comprise a description of selection an individual suitable or treatment. Instructions supplied in the kits of the invention are typically written instructions on a label or package insert (*e.g.*, a paper sheet included in the kit), but machine-readable instructions (*e.g.*, instructions carried on a magnetic or optical storage disk) are also acceptable. In some embodiments, the kit further comprises another therapeutic agent.

[0187] The kits of the invention are in suitable packaging. Suitable packaging include, but is not limited to, vials, bottles, jars, flexible packaging (*e.g.*, sealed Mylar or plastic bags), and the like. Kits may optionally provide additional components such as buffers and interpretative information. The present application thus also provides articles of manufacture, which include vials (such as sealed vials), bottles, jars, flexible packaging, and the like.

EXAMPLES

[0188] The examples discussed below are intended to be purely exemplary of the invention and should not be considered to limit the invention in any way. The examples are not intended to represent that the experiments below are all or the only experiments performed. Efforts have been made to ensure accuracy with respect to numbers used (for example, amounts, temperature, *etc.*) but some experimental errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, molecular weight is weight average molecular weight, temperature is in degrees Centigrade, and pressure is at or near atmospheric.

Example 1: Production of Afucosylated Anti-FGFR2IIIb Antibody.

[0189] *Construction of expression vector*. Nucleotide sequences encoding the heavy chain (HC) and light chain (LC) of monoclonal antibody αFGFR2b were cloned into the GS Gene Expression System (Lonza, Basel, Switzerland) according to the manufacturer's instructions. The system generates a double gene vector (DGV) containing the expression cassettes for both the light chain and the heavy chain.

[0190] *Choice of host cell line*. To generate afucosylated monoclonal antibody αFGFR2bA (the designation "A" after αFGFR2b refers to "afucosylated"), the Potelligent® CHOK1SV cells (BioWa/Lonza, Allendale, NJ) was chosen as host cell line. Potelligent® CHOK1SV cells lack

the *FUT8* gene (α1,6-fucosyltransferase) and therefore produce fucose-free antibodies (afucosylated antibodies).

[0191] *Construction of stable cell line for production of afucosylated αFGR2bA antibody*: The expression vector comprising the nucleotide sequences encoding αFGFR2b antibody heavy chain and light chain described above transfected into Potelligent® CHOK1SV cells by electroporation according to the manufacturer's instructions. Electroporated cells were seeded into a 96-well plate at about 10,000 cells/50µl/well in CD CHO medium without L-glutamine. Selective CD CHO medium containing 67 µM L-methionine sulfoximine (MSX, SIGMA cat#M5379, St. Louis, MO) was added the next day at 150 µl/well. Cell growth and clone formation was monitored with an IN Cell Analyzer 2000 (GE Healthcare, Piscataway, NJ).

[0192] After 4-6 weeks, the surviving colonies were screened for expression of αFGFR2bA antibody using a Homogenous Time Resolved Fluorescence (HTRF) based assay against standard curves generated with purified αFGFR2b antibody, using XL665 conjugated protein A and cryptate conjugated polyclonal rabbit IgG (Cisbio, Bedford, MA). The highest expressing clones were expanded through a series of increasing-scale production processes, including 24-well plates, spin tubes, shake flasks, bench scale bioreactors, and finally a platform production process. At each step, only a subset comprising the highest-expressing clones were taken on to the next process. The final production clone was selected based on the evaluation of protein product titers, cell growth characteristics, product quality, stability, as well as scalability in bioreactors. The final production line had an expression level of about 3.5g/L for αFGFR2bA. Lack of fucosylation in αFGFR2bA produced in the final production cell line was confirmed using normal phase HLPC (N-HPLC) chromatography.

[0193] αFGFR2bA antibody was purified by column chromatography and ultrafiltration to concentrate the purified material, then diafiltration to exchange into formulation buffer (20 mM histidine, 150 mM L-arginine, 0.01% polysorbate 20, pH 6.0). Antibody was stored below -70°C.

[0194] Glycan analysis of αFGFR2bA is performed by releasing the glycans from the protein, labeling the glycans with anthranilic acid (2-AA), and then purifying the labeled glycans. Normal phase HPLC with fluorescent detection is used to separate the glycans and measure the relative amount of each glycan in the antibody. Figure 7 shows that αFGFR2b derived from the Potelligent® CHOK1SV cell line and αFGFR2b produced from CHOK1SV had two different glycan distributions. (A) Glycan distribution of αFGFR2b derived from the Potelligent® CHOK1SV cell line shows that the antibody lacks fucose ("G0"). (B) Glycan distribution of

αFGFR2b derived from the CHOK1SV cell line shows that the antibody contains fucose ("G0F").

[0195] Glycan peaks from the normal phase HPLC separation were identified using two orthogonal methods. First, the Potelligent® CHOK1SV produced αFGFR2b were labeled and separated using the normal phase HPLC method. After the fluorescent detection, the glycans were passed through a QTrap mass spectrometer. The mass of each peak was determined and used to positively identify each glycan, and is shown in Table 2.

Table 2: Mass of glycan peaks

Glycan	Theoretical Mass (Da)	Observed Mass (Da)
G0	1437	1437.4
Man-5	1355	1355.3
G1	1600	1599.4

[0196] The mass of each fucosylated form of the glycans (G0F, G1F, and G2F) were also searched in the Potelligent® CHOK1SV produced αFGFR2b and were not observed. Figure 8 shows schematic diagrams of the G0, G1, G2, G0F, G1F, G2F, and mannose-5 (or Man-5) glycan structures typically observed in antibodies.

[0197] The peak identities from the HPLC assay were also confirmed using glycan standards purchased from Prozyme and matching the retention time between the standards and the αFGFR2 profiles from both the Potelligent® CHOK1SV cell line and the CHOK1SV cell line. These standards were able to identify G0, G0F, Man5, G1, G1F, and G2F.

[0198] The results from the HPLC assay as well as the characterization data confirmed the lack of fucosylation in αFGFR2 derived from the Potelligent® CHOK1SV cell line.

Example 2: Afucosylated Anti-FGFR2b Antibody Binding Affinity.

[0199] The binding affinities of αFGFR2bA and αFGFR2bF (the designation "F" after αFGFR2b refers to "fucosylated") for Fc gamma RIIIA(V158) were determined by surface plasmon resonance. Briefly, Protein A was covalently attached to a dextran chip using the Amine Coupling Kit (GE Healthcare Life Sciences, Piscataway, NJ) and 100mM ethylenediamine (Sigma) in 100mM sodium borate buffer, pH 8.0 (Sigma, St. Louis, MO) as the blocking reagent. Approximately 600-800RU of αFGFR2bA and αFGFR2bF were captured on separate flow cells and a Protein A (Pierce) derivatized flow cell served as a reference control. Fc gamma RIIIA (V158) (R&D Systems, Minneapolis, MN) was diluted in HBS-P+ running buffer (Biacore, GE Healthcare, Piscataway, NJ) and injected at 5 concentrations (0 nM, 12.3 nM, 37 nM, 111 nM, 333 nM, and 1000 nM) in duplicate. The association constant, dissociation

constant, and affinity for αFGFR2bA were calculated using the Biacore T200 Evaluation Software 1:1 binding model. The affinity constant for αFGFR2bF binding was determined using the Biacore T200 Evaluation Software steady state affinity model. The results are shown in Table 3.

Table 3: αFGFR2bA and αFGFR2bF antibody affinities for Fc gamma RIIIA(V158)

αFGFR2b	K_D (k_d/k_a) (nM)	k_a (1/Ms) x 10^3	k_d (1/ms)
A	9.2	940.1	8.6
F	207	--	--

[0200] As shown in Table 3, Fc gamma RIIIA(V158) bound αFGFR2bA with more than 20-fold greater affinity than it bound αFGFR2bF.

Example 3: Afucosylated Anti-FGFR2b Antibody ADCC Activity.

[0201] *In vitro* assays to determine the ADCC activity of αFGFR2bA antibody versus αFGFR2bF antibody were performed. Ba/F3 FGFR2IIIb-expressing target cells were produced as follows. Ba/F3 cells acquired from Leibniz-Institut DSMZ-Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH (DSMZ, cat# ACC300, Braunschweig, Germany) were maintained in RPMI (Mediatech, cat# 10-041-CV, Manassas, VA), supplemented with 10% fetal bovine serum (Mediatech, cat# 35-010-CV), 1ng/mL murine IL-3 (Peprotech, cat# 213-13, Rocky Hill, NJ), 1X BME (Invitrogen, cat# 1047574, Grand Island, NY), and 1X Penicillin-streptomycin (Mediatech cat# 30-002-Cl). The Ba/F3 cells were transfected with an expression vector that expresses FGFR2IIIb, pBNew-hFGFR2b, using Cell Line Nucleofector® Kit V (Lonza, cat# VCA-1003) following the manufacturer's protocol. pBNew vector contains a CAG promoter with a chicken β-actin intron and ampicillin and puromycin growth selection genes. Transfected cells were incubated in full growth media for 3 days then treated with 2μg/mL of puromycin (InVivoGen, cat # ant-pr-1, San Diego, CA). Puromycin selection was maintained throughout culturing. To generate individual stable clones, cells were plated at a density of 1 cell per 3 wells. Fluorescent activated cell sorting (FACS) with an anti-FGFR2IIIb antibody was used to select the clones with the highest level of FGFR2IIIb expression.

[0202] MFM-223 cells were obtained from the Health Protection Agency, UK; OCUM-2M cells were obtained from Osaka City University, Osaka, Japan; and KATO III cells were obtained from ATCC, Rockville, MD. All cells were cultured using standard methods. Freshly isolated PMBC from healthy donors were obtained from AllCells, Emeryville, CA.

[0203] ADCC assays were conducted using effector cells from 3 independent donors on 3 different days. ADCC assay testing was performed using freshly isolated human PBMCs as

effector cells at an effector to target (E/T) cell ratio of 25:1. The target cells were incubated for 16 hours in the presence of effectors and increasing concentrations of antibody. The ADCC assay was validated using 2 positive control antibodies, HERCEPTIN® on SKOV-3 target cells and RITUXIN® on Raji target cells. A fully human IgG1 negative control antibody (Eureka Therapeutics, Catalog ET901, Emeryville, CA) was used for non-specific cell cytotoxicity. Cytotoxicity was determined by quantifying LDH release as per the manufacturer's instructions (CytoTox Non Radioactive Cytotoxicity Assay, Promega, Madison, WI).

[0204] Maximal lysis was determined in the presence of 5% Triton X-100, and spontaneous release was determined in the absence of antibody. Percentage of specific lysis was calculated as follows, as a percentage of maximal lysis less spontaneous release:

(experimental – spontaneous release) / (maximal – spontaneous release) x 100 = % specific lysis

[0205] The results for the Ba/F3 cells are shown in Figure 1. Afucosylated αFGFR2bA antibody induced greater specific lysis than fucosylated αFGFR2bF antibody in FGFR2IIIb-expressing Ba/F3 cells. In OCUM-2M, MFM 223, and KATO III cells, αFGFR2bA showed greater ADCC activity at lower concentrations than αFGFR2bF, although maximal specific lysis of the antibodies was comparable in OCUM-2M and MFM 223 cells (data not shown). Further, αFGFR2b showed little to no ADCC activity in FGFR2IIIc-expressing Ba/F3 cells. *See* Figure 1A.

Example 4: Afucosylated Anti-FGFR2b Antibody Activity in Gastric Cancer and Breast Cancer Xenograft Models.

[0206] Six week old female CB17 SCID mice were purchased from Charles River Laboratories (Wilmington, MA) and were acclimated for 1 week before the start of the study. Human gastric carcinoma cell line OCUM-2M or breast carcinoma cell line MFM-223 were used as the tumor models. OCUM-2M was purchased from Public University Corporation Osaka City University (OCU, Osaka, Japan), and MFM-223 was purchased from Culture Collections, Public Health England (98050130, HPA Culture Collections, Salisbury, UK). The cells were cultured for up to three passages in complete growth medium to expand for implantation. OCUM-2M and MFM-223 cells were cultured in Dulbecco's Minimum Essential Medium (DMEM) and Minimum Essential Medium (MEM), respectively. All medium was supplemented with 10% heat-inactivated Fetal Bovine Serum (FBS), 2 mM L-Glutamine, and Penicillin-Streptomycin solution. Cells were grown at 37°C in a humidified atmosphere with 5% CO_2.

[0207] When the cultured cells reached 85-90% confluence, cells were harvested and resuspended in cold Ca^{2+} and Mg^{2+} free phosphate buffered saline (PBS) containing 50% Matrigel (BD BioSciences, San Jose, CA). OCUM-2M cells were implanted subcutaneously over the right flank of the mice at $5x10^5$ cells/100 µl/mouse. MFM-223 cells were implanted

subcutaneously over the right flank of the mice at $5x10^5$ cells/100 µl/mouse, and 0.72 mg 90-day release 17-β estradiol pellets (Innovative Research of America, Sarasota, FL) were inoculated subcutaneously into the right flank. Mice were monitored twice weekly following cell implantation for tumor growth. Tumor size was measured according to the formula: Tumor size (mm^3) = (width (mm) x length $(mm)^2$)/2. When MFM-223 tumors reached 80 mm^3 mice were sorted and randomized (n=10), and treatment was initiated. For OCUM-2M tumors, single therapy with anti-FGFR2b was initiated once tumors reached an average size of 100 mm^3, and combination therapy was initiated once tumors reached an average size of 250 mm^3.

[0208] Anti-FGFR2IIIb humanized antibody (Afucosylated, αFGFR2bA; Fucosylated, αFGFR2bF) or albumin as a negative control was administered at doses ranging from 1 to 10 mg/kg via intraperitoneal injection twice per week as specified in the figure legends. Chemotherapeutic agents were administered via intraperitoneal injection twice per week at 12 mg/kg for paclitaxel, 2.3 mg/kg for fluorouracil (5-FU), and 33 mg/kg for cisplatin. Upon initiation of therapy, tumor sizes were measured in each mouse twice weekly. The length and width of each tumor was measured using calipers and the tumor size calculated according to the formula above. Mice were euthanized when the subcutaneous tumor volumes exceeded 2000 mm^3 or when the tumors became excessively necrotic.

[0209] Comparisons of tumor volume as a consequence of were determined to be statistically significant if $P < 0.05$. *P*-values were calculated using unpaired, two-tailed t-test analyses of the calculated tumor volumes on the final day upon which tumors were measured.

[0210] Figure 2 shows efficacy of αFGFR2bA and αFGFR2bF at (A and B) 10 mg/kg and (C and D) 3 mg/kg in an OCUM-2M human gastric cancer xenograft model with FGFR2 amplification. (A) At 10 mg/kg, both fucosylated and afucosylated antibody induced immediate tumor regression. However, afucosylated αFGFR2bA induced a more durable response than fucosylated αFGFR2bF. (B) Afucosylated αFGFR2bA significantly reduced final OCUM-2M tumor size compared to fucosylated αFGFR2bF (p=0.0153). Statistical significance was determined via two-tailed, unpaired t-Test. (C) When dosed at 3 mg/kg, afucosylated αFGFR2bA reduced tumor growth compared to fucosylated αFGFR2bF. Indeed, afucosylated αFGFR2bA induced greater tumor regression and durable response compared to fucosylated αFGFR2bF (note: one animal was removed from the αFGFR2bF group at about day 42, resulting in a shift in the curve). (D) Afucosylated αFGFR2bA at 3 mg/kg compared to fucosylated αFGFR2bF notably reduced final OCUM-2M tumor size (p=0.0767). Statistical significance was determined via two-tailed, unpaired t-Test.

[0211] Figure 3 shows dose-dependent tumor inhibition by αFGFR2bA. (A) SCID mice bearing subcutaneous OCUM-2M xenografts were treated with 1, 1.5, 2, 3, or 5 mg/kg afucosylated αFGFR2bA when average tumor size reached approximately 100 mm^3. Although all doses of afucosylated αFGFR2bA inhibited tumor growth, the greatest suppression and durable response were observed with 3 and 5 mg/kg, with reduced growth suppression observed with 2, 1.5, and 1 mg/kg αFGFR2bA. (B) Afucosylated αFGFR2bA reduced final OCUM-2M tumor size, with higher doses showing more potent growth suppression. Tumor growth suppression was statistically significant for all doses (5 mg/kg, $p<0.0001$; 3 mg/kg, $p<0.0001$; 2 mg/kg, $p<0.0001$; 1.5 mg/kg, $p=0.0003$; 1 mg/kg, $p=0.0013$). Statistical significance was determined via two-tailed, unpaired t-Test.

[0212] Figure 4 shows enhancement of paclitaxel anti-tumor activity in an OCUM-2M gastric cancer xenograft model by administration with afucosylated αFGFR2bA. (A) SCID mice bearing subcutaneous OCUM-2M xenografts were treated with afucosylated αFGFR2bA (5 mg/kg), paclitaxel (12 mg/kg), or a combination of the two when average tumor size reached approximately 285 mm^3. Combining afucosylated αFGFR2bA with paclitaxel reduced tumor size compared to either αFGFR2bA or paclitaxel alone. (B) Combined αFGFR2bA/paclitaxel therapy significantly reduced final OCUM-2M tumor size compared to either paclitaxel ($p=0.0005$) or αFGFR2bA ($p=0.0009$) alone. Statistical significance was determined via two-tailed, unpaired t-Test.

[0213] Figure 5 shows enhancement of cisplatin/5-FU anti-tumor activity in an OCUM-2M gastric cancer xenograft model by administration with afucosylated αFGFR2bA. (A) SCID mice bearing subcutaneous OCUM-2M xenografts were treated with afucosylated αFGFR2bA (5 mg/kg), fluorouracil (5-FU) plus cisplatin (2.3 and 33 mg/kg, respectively), or a combination of the three when average tumor size reached approximately 260 mm^3. Combining afucosylated αFGFR2bA with 5-FU/cisplatin reduced tumor size compared to either αFGFR2bA or 5-FU/cisplatin alone. (B) Combined αFGFR2bA/5-FU/cisplatin therapy significantly reduced final OCUM-2M tumor size compared to 5-FU/cisplatin ($p=0.0003$). Increased reduction in tumor size by combined αFGFR2bA/5-FU/cisplatin therapy compared to αFGFR2bA alone was notable but not statistically significant. Statistical significance was determined via two-tailed, unpaired t-Test.

[0214] Figure 6 shows efficacy of αFGFR2bA in an MFM-223 human breast cancer xenograft model. (A) MFM-223, a human breast carcinoma cell line with FGFR2 amplification, was implanted subcutaneously into SCID mice, and afucosylated αFGFR2bA therapy was initiated when average tumor size reached approximately 80 mm^3. Afucosylated αFGFR2bA (5 mg/kg)

dramatically reduced growth of MFM-223 tumors compared to albumin control (5 mg/kg). (B) Afucosylated αFGFR2bA significantly reduced final MFM-223 tumor size compared to albumin control (p=0.0008). Statistical significance was determined via two-tailed, unpaired t-Test.

Example 5: Afucosylated Anti-FGFR2b Antibody Mediates Greater ADCC than Fucosylated Anti-FGFR2b Antibody.

[0215] *In vitro* assays to determine the ADCC activity of αFGFR2bA antibody versus αFGFR2bF antibody were performed. Ba/F3 FGFR2IIIb-expressing target cells were generated as described before. OCUM-2M cells were obtained from Osaka City University, Osaka, Japan. All cells were cultured using standard methods. Freshly isolated PMBC from healthy donors were obtained from AllCells, Emeryville, CA.

[0216] ADCC assays were conducted using freshly isolated human PBMCs as effector cells at an effector to target (E:T) cell ratio of 25:1. The target cells were incubated for 16 hours in the presence of effectors and increasing concentrations of antibody. All conditions were tested in triplicate. Cytotoxicity was determined by quantifying LDH release as per the manufacturer's recommendations (Promega's CytoTox Non-Radioactive Cytotoxicity Assay). For the OCUM-2M cells, maximal lysis was determined in the presence of 5% Triton X-100, and spontaneous release was determined in the absence of antibody. Percentage of specific lysis was calculated as a percentage of maximal lysis less spontaneous release, as follows: (experimental – spontaneous release) / (maximal – spontaneous release) x 100 = % specific lysis. GraphPad software curve-fitting analysis was used to obtain EC50 values.

[0217] The results for the Ba/F3 cells are shown in Figure 9. Afucosylated αFGFR2bA antibody showed higher potency (greater ADCC activity at lower concentrations) than fucosylated αFGFR2bF antibody in FGFR2IIIb-expressing Ba/F3 cells. Similar results are shown for OCUM-2M cells in Figure 10. Table 4 shows the potency fold increase of afucosylated anti-FGFRb antibody compared to fucosylated anti-FGFR2b antibody in the two different cell lines shown in Figures 9 and 10.

Table 4: Potency fold increase of afucosylated versus fucosylated anti-FGFR2b antibody

	EC50 (ng/mL)		
Cells	αFGFR2bA	αFGFR2bF	Potency Fold Increase of αFGFR2bA
OCUM-2M	5	30	6
BaF3 FGFR2b	2	16	8

Example 6: Immunohistochemical Detection of FGFR2IIIb Protein in Tumor Tissue.

[0218] Murine αFGFR2b antibody comprising the murine variable regions of GAL-FR21 (*see* U.S. Patent No. 8,101,723 B2) and a murine IgG2a constant region was used to detect FGFR2IIIb protein in formalin-fixed paraffin embedded (FFPE) gastric tumor tissue. FFPE tumor tissue as de-paraffinized with successive washes of xylenes and decreasing concentrations of ethanol, and rehydrated with water for five minutes. Slide-mounted tissue sections were immersed in 0.1 mM citrate buffer (pH 6.0) heated to 95°-99°C for 15 minutes. Tissue sections were cooled and contacted with 3% H_2O_2 for 5 minutes at room temperature, and then washed twice in TBST (0.05M Tris, 0.15M NaCl, 0.05% Tween 20) and blocked in blocking buffer (2.5% normal horse serum in TBST) for 30 minutes at room temperature. Tissue sections were then incubated with 5 μg/ml αFGFR2b antibody in blocking buffer for 30 minutes at room temperature. Incubation times between 30 minutes and 2 hours produced similar staining intensities. Following three washes with TBST buffer, tissue sections were incubated with ready-to-use (RTU) biotinylated secondary horse anti-mouse antibody (10 μg/ml diluted in blocking buffer (Vector Laboratories, Burlingame, CA; Cat. No. PK-7200) for 30 minutes at room temperature. Tissue sections were washed twice with TBST buffer, and the incubated with RTU streptavidin-horse radish peroxidase (HRP; Vector Laboratories, Cat. No. PK-7200) for 30 minutes at room temperature. Detection was performed using 3',3'-diaminobenzidine (DAB) substrate (Vector Laboratories, Cat. No. PK-4105) for ten minutes at room temperature per manufacturer's instructions. Tissue sections were then counter-stained with hematoxylin (Dako North America, Carpinteria, CA, Cat. No. K-8008) per manufacturer's instructions. Tissue sections were dehydrated using successive washes with increasing concentrations of ethanol and xylenes, and then covered with a coverslip.

[0219] Staining concentrations of 0.1 to 5 mg/ml αFGFR2b antibody were found to be particularly effective for protein detection.

[0220] The staining was scored as follows:

0 No staining with αFGFR2b antibody observed

1+ Faint staining is observed in samples stained with the αFGFR2b antibody. The staining is absent in corresponding sections stained with the negative control antibody.

2+ Membrane-cytoplasmic staining specific to αFGFR2b antibody is more prevalent in the sections.

3+ Strong specific staining with αFGFR2b antibody with distinct membrane localization in at least a subset of stained tumor cells.

[0221] Figure 11 shows exemplary 0 (A), 1+ (B, C), 2+ (D), and 3+ (E, F) staining of tumor tissues. In Figure 11A, ductal cells and interspersed tumor cells show an absence of staining using the αFGFR2b antibody. In Figure 11B, which shows an interstitial type gastric tumor sample, tumor cells (arrows) show some staining using the αFGFR2b antibody, while surrounding ductal cells show no staining. In Figure 11C, which shows a diffuse-type gastric tumor sample, tumor cells (arrows) show some staining using the αFGFR2b antibody, while surrounding stromal cells (arrowheads) show no staining. In Figure 11D, tumor cells (arrows) show intermediate staining using the αFGFR2b antibody, while surrounding stromal cells (arrowheads) show no staining. In Figure 11E, tumor cells (arrows) show high membrane-localized staining using the αFGFR2b antibody, while surrounding stromal cells (arrowheads) show no staining. In Figure 11F, tumor cells (arrows) show high membrane/cytoplasmic staining using the αFGFR2b antibody, while surrounding stromal cells (arrowheads) show no staining.

TABLE OF SEQUENCES

SEQ ID NO	Description	Sequence
1	Mature human FGFR2IIIb	RPSFSLVED TTLEPEEPPT KYQISQPEVY VAAPGESLEV RCLLKDAAVI SWTKDGVHLG PNNRTVLIGE YLQIKGATPR DSGLYACTAS RTVDSETWYF MVNVTDAISS GDDEDDTDGA EDFVSENSNN KRAPYWTNTE KMEKRLHAVP AANTVKFRCP AGGNPMPTMR WLKNGKEFKQ EHRIGGYKVR NQHWSLIMES VVPSDKGNYT CVVENEYGSI NHTYHLDVVE RSPHRPILQA GLPANASTVV GGDVEFVCKV YSDAQPHIQW IKHVEKNGSK YGPDGLPYLK VLKHSGINSS NAEVLALFNV TEADAGEYIC KVSNYIGQAN QSAWLTVLPK QQAPGREKEI TASPDYLEIA IYCIGVFLIA CMVVTVILCR MKNTTKKPDF SSQPAVHKLT KRIPLRRQVT VSAESSSSMN SNTPLVRITT RLSSTADTPM LAGVSEYELP EDPKWEFPRD KLTLGKPLGE GCFGQVVMAE AVGIDKDKPK EAVTVAVKML KDDATEKDLS DLVSEMEMMK MIGKHKNIIN LLGACTQDGP LYVIVEYASK GNLREYLRAR RPPGMEYSYD INRVPEEQMT FKDLVSCTYQ LARGMEYLAS QKCIHRDLAA RNVLVTENNV MKIADFGLAR DINNIDYYKK TTNGRLPVKW MAPEALFDRV YTHQSDVWSF GVLMWEIFTL GGSPYPGIPV EELFKLLKEG HRMDKPANCT NELYMMMRDC WHAVPSQRPT FKQLVEDLDR ILTLTTNEEY LDLSQPLEQY SPSYPDTRSS CSSGDDSVFS PDPMPYEPCL PQYPHINGSV KT
2	αFGFR2b heavy chain; Asn297 is in bold and underlined	QVQLVQSGAE VKKPGSSVKV SCKASGYIFT TYNVHWVRQA PGQGLEWIGS IYPDNGDTSY NQNFKGRATI TADKSTSTAY MELSSLRSED TAVYYCARGD FAYWGQGTLV TVSSASTKGP SVFPLAPSSK STSGGTAALG CLVKDYFPEP VTVSWNSGAL TSGVHTFPAV LQSSGLYSLS SVVTVPSSSL GTQTYICNVN HKPSNTKVDK RVEPKSCDKT HTCPPCPAPE LLGGPSVFLF PPKPKDTLMI SRTPEVTCVV VDVSHEDPEV KFNWYVDGVE VHNAKTKPRE EQYNSTYRVV SVLTVLHQDW LNGKEYKCKV SNKALPAPIE KTISKAKGQP REPQVYTLPP SREEMTKNQV SLTCLVKGFY PSDIAVEWES NGQPENNYKT TPPVLDSDGS FFLYSKLTVD KSRWQQGNVF SCSVMHEALH NHYTQKSLSL SPGK
3	αFGFR2b light chain	DIQMTQSPSS LSASVGDRVT ITCKASQGVS NDVAWYQQKP GKAPKLLIYS ASYRYTGVPS RFSGSGSGTD FTFTISSLQP EDIATYYCQQ HSTTPYTFGQ GTKLEIKRTV AAPSVFIFPP SDEQLKSGTA SVVCLLNNFY PREAKVQWKV DNALQSGNSQ ESVTEQDSKD STYSLSSTLT LSKADYEKHK VYACEVTHQG LSSPVTKSFN RGEC
4	αFGFR2b heavy chain variable region	QVQLVQSGAE VKKPGSSVKV SCKASGYIFT TYNVHWVRQA PGQGLEWIGS IYPDNGDTSY NQNFKGRATI TADKSTSTAY MELSSLRSED TAVYYCARGD FAYWGQGTLV TVSS
5	αFGFR2b light chain variable region	DIQMTQSPSS LSASVGDRVT ITCKASQGVS NDVAWYQQKP GKAPKLLIYS ASYRYTGVPS RFSGSGSGTD FTFTISSLQP EDIATYYCQQ HSTTPYTFGQ GTKLEIK
6	αFGFR2b heavy chain (HC) HVR1	TYNVH
7	αFGFR2b HC HVR2	SIYPDNGDTS YNQNFKG
8	αFGFR2b HC HVR3	GDFAY

9	αFGFR2b light chain (LC) HVR1	KASQGVSNDV A
10	αFGFR2b LC HVR2	SASYRYT
11	αFGFR2b LC HVR3	QQHSTTPYT
12	Mature human FGFR2IIIc	RPSFSLVED TTLEPEEPPT KYQISQPEVY VAAPGESLEV RCLLKDAAVI SWTKDGVHLG PNNRTVLIGE YLQIKGATPR DSGLYACTAS RTVDSETWYF MVNVTDAISS GDDEDDTDGA EDFVSENSNN KRAPYWTNTE KMEKRLHAVP AANTVKFRCP AGGNPMPTMR WLKNGKEFKQ EHRIGGYKVR NQHWSLIMES VVPSDKGNYT CVVENEYGSI NHTYHLDVVE RSPHRPILQA GLPANASTVV GGDVEFVCKV YSDAQPHIQW IKHVEKNGSK YGPDGLPYLK VLKAAGVNTT DKEIEVLYIR NVTFEDAGEY TCLAGNSIGI SFHSAWLTVL PAPGREKEIT ASPDYLEIAI YCIGVFLIAC MVVTVILCRM KNTTKKPDFS SQPAVHKLTK RIPLRRQVTV SAESSSSMNS NTPLVRITTR LSSTADTPML AGVSEYELPE DPKWEFPRDK LTLGKPLGEG CFGQVVMAEA VGIDKDKPKE AVTVAVKMLK DDATEKDLSD LVSEMEMMKM IGKHKNIINL LGACTQDGPL YVIVEYASKG NLREYLRARR PPGMEYSYDI NRVPEEQMTF KDLVSCTYQL ARGMEYLASQ KCIHRDLAAR NVLVTENNVM KIADFGLARD INNIDYYKKT TNGRLPVKWM APEALFDRVY THQSDVWSFG VLMWEIFTLG GSPYPGIPVE ELFKLLKEGH RMDKPANCTN ELYMMMRDCW HAVPSQRPTF KQLVEDLDRI LTLTTNEEYL DLSQPLEQYS PSYPDTRSSC SSGDDSVFSP DPMPYEPCLP QYPHINGSVK T

CLAIMS

1. A composition comprising a plurality of anti-FGFR2IIIb antibodies, wherein each anti-FGFR2IIIb antibody comprises heavy chain and light chain variable regions, wherein the heavy chain variable region comprises:

(i) HVR-H1 comprising the amino acid sequence of SEQ ID NO: 6;

(ii) HVR-H2 comprising the amino acid sequence of SEQ ID NO: 7; and

(iii) HVR-H3 comprising the amino acid sequence of SEQ ID NO: 8;

and the light chain variable region comprises:

(iv) HVR-L1 comprising the amino acid sequence of SEQ ID NO: 9;

(v) HVR-L2 comprising the amino acid sequence of SEQ ID NO: 10; and

(vi) HVR-L3 comprising the amino acid sequence of SEQ ID NO: 11;

wherein at least 95% of the anti-FGFR2IIIb antibodies in the composition are afucosylated.

2. The composition of claim 1, wherein the heavy chain variable domain comprises the amino acid sequence of SEQ ID NO: 4.

3. The composition of claim 1 or claim 2, wherein the light chain variable domain comprises the amino acid sequence of SEQ ID NO: 5.

4. The composition of claim 1, wherein the heavy chain variable domain comprises the amino acid sequence of SEQ ID NO: 4 and the light chain variable domain comprises the amino acid sequence of SEQ ID NO: 5.

5. The composition of any one of claims 1 to 4, wherein the heavy chain comprises the amino acid sequence of SEQ ID NO: 2.

6. The composition of any one of claims 1 to 5, wherein the light chain comprises the amino acid sequence of SEQ ID NO: 3.

7. The composition of claim 1, wherein the heavy chain comprises the amino acid sequence of SEQ ID NO: 2 and the light chain comprises the amino acid sequence of SEQ ID NO: 3.

8. The composition of any one of claims 1 to 7, wherein the antibodies are monoclonal antibodies.

9. The composition of any one of claims 1 to 8, wherein the antibodies are chimeric antibodies.

10. The composition of any one of claims 1 to 9, wherein the antibodies are humanized antibodies.

11. The composition of any one of claims 1 to 10, wherein the antibodies lack fucose at Asn297.

12. The composition of any one of claims 1 to 11, wherein the antibodies comprise a κ light chain constant region.

13. The composition of any one of claims 1 to 12, wherein the antibodies comprise an IgG1 heavy chain constant region.

14. The composition of any one of claims 1 to 13, wherein the afucosylated antibodies have enhanced ADCC activity *in vitro* compared to a fucosylated anti-FGFR2IIIb antibody having the same amino acid sequence.

15. The composition of claim 14, wherein the afucosylated anti-FGFR2IIIb antibodies cause specific lysis that is at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 60, at least 65, at least 70, or at least 75 percentage points greater than specific lysis with the fucosylated anti-FGFR2IIIb antibody.

16. The composition of claim 14 or claim 15, wherein ADCC activity is determined using Ba/F3 cells expressing FGFR2IIIb as target cells and isolated human PBMCs as effector cells.

17. The composition of any one of claims 1 to 16, wherein the afucosylated antibodies have enhanced affinity for Fc gamma RIIIA compared to a fucosylated anti-FGFR2IIIb antibody having the same amino acid sequence.

18. The composition of claim 17, wherein the afucosylated anti-FGFR2IIIb antibodies bind to Fc gamma RIIIA with at least 2-fold, at least 3-fold, at least 4-fold, at least 5-fold, at least 7-fold, at least 10-fold, at least 12-fold, at least 15-fold, at least 17-fold, or at least 20-fold greater affinity than the fucosylated anti-FGFR2IIIb antibody.

19. The composition of claim 17 or claim 18, wherein affinity for Fc gamma RIIIA is determined using surface plasmon resonance.

20. The composition of any one of claims 17 to 19, wherein Fc gamma RIIIA is selected from Fc gamma RIIIA(V158) and Fc gamma RIIIA(F158).

21. The composition of claim 20, wherein Fc gamma RIIIA is Fc gamma RIIIA(V158).

22. The composition of any one of claims 1 to 21, wherein the afucosylated anti-FGFR2IIIb antibodies bind FGFR2IIIb but do not bind to FGFR2IIIc.

23. A host cell comprising nucleic acid encoding anti-FGFR2IIIb antibodies of any one of claims 1 to 22, wherein the host cell lacks a functional alpha-1,6-fucosyltransferase gene (FUT8) gene.

24. The host cell of claim 23, which is a CHO cell.

25. A method for making afucosylated anti-FGFR2IIIb antibodies, said method comprising culturing the host cell of claim 23 or claim 24 under conditions suitable for expressing nucleic acid encoding anti-FGFR2IIIb antibodies.

26. A method for making afucosylated anti-FGFR2IIIb antibodies, comprising culturing the host cell of claim 23 or claim 24 under conditions suitable for producing afucosylated anti-FGFR2IIIb antibodies.

27. The method of claim 25 or 26, further comprising recovering the anti-FGFR2IIIb antibody produced by the host cell.

28. The method of any one of claims 25 to 27, wherein at least 95% of the anti-FGFR2IIIb antibodies produced by the host cell are afucosylated.

29. The method of claim 28, wherein fucose is undetectable in the anti-FGFR2IIIb antibodies produced by the host cell.

30. The method of claim 28 or claim 29, wherein fucose is assayed by a method comprising HPLC, capillary electrophoresis, or MALDI-TOF mass spectrometry.

31. A pharmaceutical composition comprising the composition of any one of claims 1 to 22 and a pharmaceutically acceptable carrier.

32. Use of a composition of any one of claims 1-22 or of a pharmaceutical composition of claim 31 in the manufacture of a medicament for treating cancer in an individual in need thereof.

33. The use of claim 32, wherein the cancer is a solid tumor.

34. The use of claim 32 or 33, wherein the cancer is selected from gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, or esophageal cancer.

35. The use of claim 34, wherein the cancer is gastric cancer.

36. The use of any one of claims 32 to 35, wherein the cancer overexpresses FGFR2IIIb.

37. The use of claim 36, wherein FGFR2IIIb expression is determined by immunohistochemistry (IHC).

38. The use of claim 36 or claim 37, wherein the cancer does not comprise FGFR2 gene amplification.

39. The use of any one of claims 32 to 37, wherein the cancer comprises an FGFR2 gene amplification.

40. The use of any one of claims 32 to 38, wherein the treatment further comprises administering at least one additional therapeutic agent selected from a platinum agent, paclitaxel, ABRAXANE®, docetaxel, gemcitabine, capecitabine, irinotecan, epirubicin, FOLFOX, FOLFIRI, leucovorin, fluorouracil, mitomycin C, and doxorubicin hydrochloride.

41. The use of claim 40, wherein the at least one additional therapeutic agent is a platinum agent and the platinum agent is selected from cisplatin, oxaliplatin, and carboplatin.

42. The use of claim 40, wherein the additional therapeutic agent is paclitaxel.

43. The use of claim 40, wherein the additional therapeutic agent is cisplatin and/or 5-FU.

44. The use of claim 40, wherein the additional therapeutic agent is FOLFOX.

45. A pharmaceutical composition for treating cancer comprising an effective amount of anti-FGFR2IIIb antibodies of any one of claims 1 to 22 and a pharmaceutically acceptable carrier.

46. The pharmaceutical composition of claim 45, wherein the cancer is a solid tumor.

47. The pharmaceutical composition of claim 45 or claim 46, wherein the cancer is selected from gastric cancer, breast cancer, ovarian cancer, endometrial cancer, pancreatic cancer, and esophageal cancer.

48. The pharmaceutical composition of claim 47, wherein the cancer is gastric cancer.

49. The pharmaceutical composition of any one of claims 45 to 48, wherein the cancer overexpresses FGFR2IIIb.

50. The pharmaceutical composition of claim 49, wherein FGFR2IIIb expression is determined by immunohistochemistry (IHC).

51. The pharmaceutical composition of claim 49 or claim 50, wherein the cancer does not comprise FGFR2 gene amplification.

52. The pharmaceutical composition of any one of claims 45 to 51, wherein the cancer comprises an FGFR2 gene amplification.