a human cardiac-derived progenitor cell (hCMPC), a tumor cell, or other animal cell. In some embodiments, the cell is from a mammal. In some embodiments, the cell is from a human.

[0009a] Also provided herein, is a composition comprising a cell deficient in one or more genes recited in Tables 1, 2, 4, or 5, wherein the cell is deficient in one or more of chondroitin sulfate synthase 1 (ChSy), Chondroitin Sulfate N-Acetylgalactosaminyltransferase 2 (CSGalNAcT2), Chondroitin Polymerizing Factor (ChPF), heparan sulfate 2-O-sulphotransferase (HS2ST), glucuronic acid epimerase (GLCE), heparan sulfate N-deacetylase/sulfotransferase-1 (HSNDST1), heparan sulfate N-deacetylase/sulfotransferase-2 (HSNDST2), Sulfatase 1 (Sulf1), Sulfatase (Sulf2), Beta-glucuronidase (GUSB), Galactosamine-6 sulfatase (GALNS), Alpha-L-iduronidase (IDUA), Sulfamidase (SGSH), N-acetyltransferase (AANAT, ARD1A, GNPNAT1, HGSNAT, MAK10, NAT1, NAT2, NAT5, NAT6, NAT8, NAT8L, NAT9, NAT10, NAT11, NAT12, NAT13, NAT14, NAT14), Uronate-2-sulfatase (IDS), Alpha-N-acetylglucosaminidase (NAGLU), PAPS synthase (PAPSS1, PAPSS2), Xylosyltransferase 1 (XYLT1), Xylosyltransferase 2 (XYLT2), Galactosyltransferase 1 (B4GALT1), Galactosyltransferase 2 (B4GALT2), Glucuronyltransferase 1 (UDPGT), Exostosin-Like Glycosyltransferase 3 (EXTL3), Exostosin Glycosyltransferase 1 (EXT1), Exostosin Glycosyltransferase 2 (EXT2), Heparanase (HPSE), Glypican 1 (GPC1), Glypican 2 (GPC2), Glypican 3 (GPC3), Glypican 4 (GPC4), Glypican 5 (GPC5), Glypican 6 (GPC6), Syndecan 1 (SDC1), Syndecan 2 (SDC2), Syndecan 3 (SDC3), Syndecan 4 (SDC4), Betaglycan (BGCAN/TGFBR3), CD44V3 (CD44V3), Neuropillin 1 (NRP1), Serglycin (SRGN), Perlecan (PLC), Agrin (AGRN), Collagen 18 (COL18A1), GalNAc transferase 2 (CSGalNAcT2), Chondroitin sulfate synthase 1 (Chsy1), Chondroitin sulfate synthase 3 (Chsy3), Chondroitin sulfate polymerizing factor (Chpf), Chondroitin sulfate polymerizing factor (Chpf2), Chondroitn 4-O-sulfotransferase 1 (Chst11), Chondroitin 4-O-sulfotransferase 2 (Chst12), Chondroitin 4-O-sulfotransferase 3 (Chst13), Chondroitin 4-sulfate 6-O-sulfotransferase (Chst15;), Chondroitin 6 sulfotransferase-1 (Chst3), Chondroitin 6-O-sulfotransferase 2 (Chst7), Dermatan sulfate glucuronyl C5 epimerase 1 (Dse), Dermatan sulfate glucuronyl C5 epimerase-like (Dsel), Dermatan sulfate 4-O-sulfotransferase (Chst14), Aggrecan (CSPG1) (Agc1), Versican/PG-M (CSPG2) (Vcan), Neurocan (CSPG3) (Ncan), Brevican (BCAN) (Bcan), Epiphycan (Dspg3) (Epyc), Procollagen, type IX, alpha 2 (Col9a2), DSD-1-proteoglycan, Phosphacan (Ptprz1), Thrombomodulin (Thbd), Endocan (Esm1), Leprecan (Prolyl 3-hydroxylase 1) (Lepre1), Decorin (Dcn), Biglycan (Bgn), Testican 1 (Spock1; osteonectin1) (Spock1), osteonectin2 (Spock2), Testican 2 (Spock3; osteonectn3) (Spock3), Proteoglycan-4 (Lubricin) (Prg4), NG2 (CSPG4) (Cspg4), or Invariant chain (Cd74).

[0010] Also provided herein, are methods of preparation of a substantially pure glycosaminoglycan selected from the group consisting of heparan sulfate, chondroitin sulfate, dermatan sulfate, keratan sulfate, and hyaluronic acid comprising use of any one of the cell lines of any one of the above embodiments, wherein the method comprises the steps: (a) growing any one of the cell lines of any one of the above embodiments, using an appropriate growth media, (b) isolating the growth media from the cells by centrifugation. In some embodiments, the

glycosaminoglycan is heparan sulfate. In some embodiments, the heparan sulfate is substantially free from chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid. In some embodiments, the glycosaminoglycan is chondroitin sulfate. In some embodiments, the chondroitin sulfate is substantially free from heparan sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid. In some embodiments, the glycosaminoglycan is dermatan sulfate. In some embodiments, the dermatan sulfate is substantially free from chondroitin sulfate, heparan sulfate, keratan sulfate, and/or hyaluronic acid. In some embodiments, the glycosaminoglycan is keratan sulfate. In some embodiments, the keratan sulfate is substantially free from chondroitin sulfate, dermatan sulfate, heparan sulfate, and/or hyaluronic acid. In some embodiments, the glycosaminoglycan is hyaluronic acid. In some embodiments, the hyaluronic acid is substantially free from chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or heparan sulfate. In some embodiments, the method comprises fractionating the mixture by ion exchange column. In some embodiments, the method comprises removing contaminating nucleic acids by nuclease digestion. In some embodiments, the method comprises removing contaminating proteins by protease digestion. In some embodiments, the method comprises fractionating the resulting product by ion exchange. In some embodiments, the method comprises desalting. In some embodiments, the method does not require the use of an enzyme. In some embodiments, the method does not require the use of a chondroitinase. In some embodiments, the glycosaminoglycan is at least 95% free from protein and nucleic acid contamination. In some embodiments, the glycosaminoglycan is at least 99% free from protein and nucleic acid contamination.

[0011] Also provided herein are methods of making a cell line capable of producing a substantially pure glycosaminoglycan selected from the group consisting of heparan sulfate, chondroitin sulfate, dermatan sulfate, keratan sulfate, and hyaluronic acid comprising genetically modifying a cell line to be transgenic or deficient for a gene of Tables 1, 2, 4 or 5. In some embodiments, the glycosaminoglycan is heparan sulfate. In some embodiments, the heparan sulfate is substantially free from chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or

WHAT IS CLAIMED IS:

1. A composition comprising a cell deficient in one or more genes recited in Tables 1, 2, 4, or 5, wherein the cell is deficient in one or more of chondroitin sulfate synthase 1 (ChSy), Chondroitin Sulfate N-Acetylgalactosaminyltransferase 2 (CSGalNAcT2), Chondroitin Polymerizing Factor (ChPF), heparan sulfate 2-O-sulphotransferase (HS2ST), glucuronic acid epimerase (GLCE), heparan sulfate N-deacetylase/sulfotransferase-1 (HSNDST1), heparan sulfate N-deacetylase/sulfotransferase-2 (HSNDST2), Sulfatase 1 (Sulf1), Sulfatase (Sulf2), Beta-glucuronidase (GUSB), Galactosamine-6 sulfatase (GALNS), Alpha-L-iduronidase (IDUA), Sulfamidase (SGSH), N-acetyltransferase (AANAT, ARD1A, GNPNAT1, HGSNAT, MAK10, NAT1, NAT2, NAT5, NAT6, NAT8, NAT8L, NAT9, NAT10, NAT11, NAT12, NAT13, NAT14, NAT14), Uronate-2-sulfatase (IDS), Alpha-N-acetylglucosaminidase (NAGLU), PAPS synthase (PAPSS1, PAPSS2), Xylosyltransferase 1 (XYLT1), Xylosyltransferase 2 (XYLT2), Galactosyltransferase 1 (B4GALT1), Galactosyltransferase 2 (B4GALT2), Glucuronyltransferase 1 (UDPGT), Exostosin-Like Glycosyltransferase 3 (EXTL3), Exostosin Glycosyltransferase 1 (EXT1), Exostosin Glycosyltransferase 2 (EXT2), Heparanase (HPSE), Glypican 1 (GPC1), Glypican 2 (GPC2), Glypican 3 (GPC3), Glypican 4 (GPC4), Glypican 5 (GPC5), Glypican 6 (GPC6), Syndecan 1 (SDC1), Syndecan 2 (SDC2), Syndecan 3 (SDC3), Syndecan 4 (SDC4), Betaglycan (BGCAN/TGFBR3), CD44V3 (CD44V3), Neuropillin 1 (NRP1), Serglycin (SRGN), Perlecan (PLC), Agrin (AGRN), Collagen 18 (COL18A1), GalNAc transferase 2 (CSGalNAcT2), Chondroitin sulfate synthase 1 (Chsy1), Chondroitin sulfate synthase 3 (Chsy3), Chondroitin sulfate polymerizing factor (Chpf), Chondroitin sulfate polymerizing factor (Chpf2), Chondroitn 4-O-sulfotransferase 1 (Chst11), Chondroitin 4-O-sulfotransferase 2 (Chst12), Chondroitin 4-O-sulfotransferase 3 (Chst13), Chondroitin 4-sulfate 6-O-sulfotransferase (Chst15;), Chondroitin 6 sulfotransferase-1 (Chst3), Chondroitin 6-O-sulfotransferase 2 (Chst7), Dermatan sulfate glucuronyl C5 epimerase 1 (Dse), Dermatan sulfate glucuronyl C5 epimerase-like (Dsel), Dermatan sulfate 4-O-sulfotransferase (Chst14), Aggrecan (CSPG1) (Agc1), Versican/PG-M (CSPG2) (Vcan), Neurocan (CSPG3) (Ncan), Brevican (BCAN) (Bcan), Epiphycan (Dspg3) (Epyc), Procollagen, type IX, alpha 2 (Col9a2), DSD-1-proteoglycan, Phosphacan (Ptprz1), Thrombomodulin (Thbd), Endocan (Esm1), Leprecan (Prolyl 3-hydroxylase 1) (Lepre1), Decorin (Dcn), Biglycan (Bgn), Testican 1 (Spock1; osteonectin1) (Spock1), osteonectin2 (Spock2), Testican 2 (Spock3; osteonectn3) (Spock3), Proteoglycan-4 (Lubricin) (Prg4), NG2 (CSPG4) (Cspg4), or Invariant chain (Cd74).

2. The composition of claim 1, wherein the cell is deficient in chondroitin sulfate synthase 1 (ChSy1).

3. The composition of claim 1 or claim 2, wherein the cell is deficient in chondroitin sulfate.

4. The composition of any one of claims 1 to 3, wherein the cell is deficient in heparan sulfate.

5. The composition of any one of claims 1 to 4, wherein the cell is deficient in dermatan sulfate.

6. The composition of any one of claims 1 to 5, wherein the cell is deficient in keratan sulfate.

7. The composition of any one of claims 1 to 6, wherein the cell is deficient in hyaluronic acid.

8. The composition of any one of claims 1 to 7, wherein the cell is transgenic for one or more genes recited in Tables 1, 2, 4 or 5, wherein the cell is transgenic for one or more of chondroitin sulfate synthase 1 (ChSy), Chondroitin Sulfate N-Acetylgalactosaminyltransferase 2 (CSGalNAcT2), Chondroitin Polymerizing Factor (ChPF), heparan sulfate 2-O-sulphotransferase (HS2ST), glucuronic acid epimerase (GLCE), heparan sulfate N-deacetylase/sulfotransferase-1 (HSNDST1), heparan sulfate N-deacetylase/sulfotransferase-2 (HSNDST2), Sulfatase 1 (Sulf1), Sulfatase (Sulf2), Beta-glucuronidase (GUSB), Galactosamine-6 sulfatase (GALNS), Alpha-L-iduronidase (IDUA), Sulfamidase (SGSH), N-acetyltransferase (AANAT, ARD1A, GNPNAT1, HGSNAT, MAK10, NAT1, NAT2, NAT5, NAT6, NAT8, NAT8L, NAT9, NAT10, NAT11, NAT12, NAT13, NAT14, NAT14), Uronate-2-sulfatase (IDS), Alpha-N-acetylglucosaminidase (NAGLU), PAPS synthase (PAPSS1, PAPSS2), Xylosyltransferase 1 (XYLT1), Xylosyltransferase 2 (XYLT2), Galactosyltransferase 1 (B4GALT1), Galactosyltransferase 2 (B4GALT2), Glucuronyltransferase 1 (UDPGT), Exostosin-Like Glycosyltransferase 3 (EXTL3), Exostosin Glycosyltransferase 1 (EXT1), Exostosin Glycosyltransferase 2 (EXT2), Heparanase (HPSE), Glypican 1 (GPC1), Glypican 2 (GPC2), Glypican 3 (GPC3), Glypican 4 (GPC4), Glypican 5 (GPC5), Glypican 6 (GPC6), Syndecan 1 (SDC1), Syndecan 2 (SDC2), Syndecan 3 (SDC3), Syndecan 4 (SDC4), Betaglycan (BGCAN/TGFBR3), CD44V3 (CD44V3), Neuropillin 1 (NRP1), Serglycin (SRGN), Perlecan (PLC), Agrin (AGRN), Collagen 18 (COL18A1), GalNAc transferase 2 (CSGalNAcT2), Chondroitin sulfate synthase 1 (Chsy1), Chondroitin sulfate synthase 3 (Chsy3), Chondroitin sulfate polymerizing factor (Chpf), Chondroitin sulfate polymerizing factor (Chpf2), Chondroitn 4-O-sulfotransferase 1 (Chst11), Chondroitin 4-O-sulfotransferase 2 (Chst12), Chondroitin 4-O-sulfotransferase 3 (Chst13), Chondroitin 4-sulfate 6-O-sulfotransferase (Chst15;), Chondroitin 6 sulfotransferase-1 (Chst3), Chondroitin 6-O-sulfotransferase 2 (Chst7), Dermatan sulfate glucuronyl C5 epimerase 1 (Dse), Dermatan sulfate glucuronyl C5

epimerase-like (Dsel), Dermatan sulfate 4-O-sulfotransferase (Chst14), Aggrecan (CSPG1) (Agc1), Versican/PG-M (CSPG2) (Vcan), Neurocan (CSPG3) (Ncan), Brevican (BCAN) (Bcan), Epiphycan (Dspg3) (Epyc), Procollagen, type IX, alpha 2 (Col9a2), DSD-1-proteoglycan, Phosphacan (Ptprz1), Thrombomodulin (Thbd), Endocan (Esm1), Leprecan (Prolyl 3-hydroxylase 1) (Lepre1), Decorin (Dcn), Biglycan (Bgn), Testican 1 (Spock1; osteonectin1) (Spock1), osteonectin2 (Spock2), Testican 2 (Spock3; osteonectn3) (Spock3), Proteoglycan-4 (Lubricin) (Prg4), NG2 (CSPG4) (Cspg4), or Invariant chain (Cd74).

9. The composition of any one of claims 1 to 8, wherein the cell produces a heparan sulfate composition substantially free from chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid.

10. The composition of any one of claims 1 to 8, wherein the cell produces a chondroitin sulfate composition substantially free from heparan sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid.

11. The composition of any one of claims 1 to 8, wherein the cell produces a dermatan sulfate composition substantially free from chondroitin sulfate, heparan sulfate, keratan sulfate, and/or hyaluronic acid.

12. The composition of any one of claims 1 to 8, wherein the cell produces a keratan sulfate composition substantially free from chondroitin sulfate, dermatan sulfate, heparan sulfate, and/or hyaluronic acid.

13. The composition of any one of claims 1 to 8, wherein the cell produces a hyaluronic acid composition substantially free from chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or heparan sulfate.

14. The composition of any one of claims 1 to 13, wherein the cell produces a heparan sulfate, chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid with a defined pattern of sulfation.

15. The composition of any one of claims 1 to 14, wherein the cell produces a heparan sulfate, chondroitin sulfate, dermatan sulfate, keratan sulfate, and/or hyaluronic acid that is at least 95% free from protein and nucleic acid contamination.

16. The composition of any one of claims 1 to 15, wherein the cell is a CHO cell, a mouse embryonic fibroblast, a 293 cell, a HeLa cell, a human fibroblast, a human embryonic stem cell, a stem cell, a an F9 cell, a human cardiac-derived progenitor cell (hCMPC), a tumor cell, or other animal cell.

17. A method of preparation of a substantially pure glycosaminoglycan selected from the group consisting of heparan sulfate, chondroitin sulfate, dermatan sulfate, keratan sulfate, and hyaluronic acid comprising use of the cell line of any one of claims 1 to 16, wherein the method

comprises the steps: (a) growing the cell line of any one of claims 1 to 16, using an appropriate growth media, (b) isolating the growth media from the cells by centrifugation

18. The method of claim 17, wherein the method comprises fractionating the growth media by ion exchange column.

19. The method of claim 17 or claim 18, wherein the method does not require the use of a chondroitinase.

20. The method of any one of claims 17 to 19, wherein the glycosaminoglycan is at least 95% free from protein and nucleic acid contamination.