CLAIMS

What is claimed is:

1. A bioreactor comprising a plurality of alternating growth substrates and spacer substrates, wherein a ratio of an area of the growth substrates to an area of the spacer substrates is 1000:1 to 1:1.

2. The bioreactor of claim 1, wherein the ratio of the area of the growth substrates to the area of the spacer substrates is 200:1 to 2:1.

3. The bioreactor of claim 1 or claim 2, further comprising a container to be partially filled with a growth medium such that at a given time point a first portion of each of the substrates is disposed in the growth medium and a second portion of the substrates is not disposed in the growth medium.

4. The bioreactor of any one of claims 1 to 3, wherein the growth substrates comprise a mesh.

5. The bioreactor of claim 4, wherein the mesh is at least a 10 × 10 mesh size.

6. The bioreactor of any one of claims 1 to 5, wherein the spacer substrates comprise a mesh.

7. The bioreactor of claim 6, wherein the mesh is at least a 1 × 1 mesh size.

8. The bioreactor of any one of claims 1 to 7, wherein the growth substrates have an average pore size greater than an average pore size of the spacer substrates.

9. The bioreactor of any one of claims 1 to 8, wherein the plurality of cell-culture substrates are formed from a material comprising stainless steel, 304L stainless steel, 316 stainless steel, 430 stainless steel, titanium, borosilicate glass, titanium dioxide ceramic, a corrosion-resistant metal, a corrosion-resistant metal alloy, Ultem™ 1010, polyethylene terephthalate, poly(glycolic acid) (PGA), poly(L-lactic acid) (PLLA), poly(lactide-co-glycolide) (PLGA), polycaprolactone (PCL), polyglycerol sebacate (PGS), a sugar-based material, a carbohydrate-based material, a protein-based material, a fat-based material, pectin, chitosan, a grain-based product, a rice-based product, a corn-based product, a wheat-based product, a seaweed-based product, an algae-based product, a degradable material, an edible material, or a combination thereof.

10. The bioreactor of any one of claims 1 to 9, wherein the growth substrates are formed from a first material and the spacer substrates are formed from a second material, the first material being different than the second material.

11. The bioreactor of any one of claims 1 to 10, wherein the growth substrates comprise a coating that selectively adheres to the cells.

12. The bioreactor of claim 11, wherein the coating comprises a cell-adhesive protein, a cell-adhesive peptide, a coating derived from an animal cell extracellular matrix, collagen, fibronectin, laminin, poly-L-lysine, poly-D-lysine, a coating derived from a plant, arginine-glycine-aspartic acid (RGD)-containing vitronectin-like protein, or a combination thereof.

13. The bioreactor of any one of claims 1 to 12, wherein each of the growth substrates is located at a distance of 1 μm to 5,000 μm from an adjacent spacer substrate.

14. The bioreactor of any one of claims 1 to 13, wherein the growth substrates are arranged substantially parallel to the spacer substrates.

15. The bioreactor of any one of claims 1 to 13, wherein a first growth substrate is arranged at an angle of 5 degrees to 45 degrees to an adjacent spacer substrate of the spacer substrates.

16. The bioreactor of any one of claims 1 to 15, further comprising a shaft coupled to the plurality of cell-culture substrates.

17. The bioreactor of claim 16, further comprising a motor coupled to the shaft to rotate the shaft, thereby rotating the plurality of cell-culture substrates.

18. The bioreactor of claim 17, wherein the motor comprises a servomotor or a stepper motor.

19. The bioreactor of any one of claims 16 to 18, wherein the shaft is coupled to a lateral center of the growth substrates.

20. The bioreactor of any one of claims 16 to 19, wherein the shaft is coupled to a lateral center of the spacer substrates.

21. The bioreactor of any one of claims 1 to 20, wherein the growth substrates are for the growth of a biological material.

22. The bioreactor of claim 21, wherein the biological material comprises cells, tissues, organs, cell-based meat, cell-based fat, or a combination thereof.

23. The bioreactor of any one of claims 1 to 22, wherein a lateral area of a growth substrate of the growth substrates comprises a shape selected from the group consisting of: circle, ellipse, rectangle, square, diamond, triangle, and polygon.

24. The bioreactor of any one of claims 1 to 23, wherein a lateral area of a spacer substrate of the spacer substrates comprises a shape selected from the group consisting of: circle, ellipse, rectangle, square, diamond, triangle, and polygon.

25. The bioreactor of any one of claims 3 to 24, wherein at least a portion of an interior of the container conforms to a shape of the growth substrates or a shape of the spacer substrates.

26. The bioreactor of any one of claims 3 to 25, wherein the container comprises a sealable container.

27. The bioreactor of claim 26, wherein the sealable container comprises a hermetically sealable container.

28. The bioreactor of any one of claims 3 to 27, wherein the container isolates the growth medium from an environment surrounding the container.

29. A cell cultivation system comprising:

at least one growth substrate for growing one or more cell types, the at least one growth substrate having a mesh porosity and a surface area such that a higher cell growth density per unit area is achieved when using a growth substrate that has a higher mesh porosity and a smaller surface area unit area than another growth substrate.

30. The system of claim 29, wherein the mesh porosity and the surface area per unit area are based on a number of openings in the at least one growth substrate.

31. The system of claim 30, wherein the openings are arranged in a repeating pattern across a surface of the at least one growth substrate.

32. The system of claim 30, wherein the cell growth density per unit area on the at least one growth substrate increases with the number of openings.

33. The system of claim 32, wherein the cell growth density per unit area on the at least one growth substrate increases by at least 5% when the number of openings is increased by at least 10%.

34. The system of claim 30, wherein the cell growth density per unit area on the at least one growth substrate increases with decreasing surface area per unit area.

35. The system of claim 34, wherein the cell growth density per unit area on the at least one growth substrate increases by at least 5% when the surface area per unit area is decreased by at least 10%.

36. The system of claim 29, further comprising at least one spacer substrate adjacent to the at least one growth substrate.

37. The system of claim 36, where the at least one spacer substrate is used to facilitate transport and distribution of a growth medium over or across a surface of the at least one growth substrate.

38. A cell cultivation system comprising:

at least one growth substrate for growing one or more cell types; and

at least one spacer substrate adjacent to the at least one growth substrate, the at least one spacer substrate being sized to influence a cell growth density on the at least one growth substrate, such that a higher cell growth density per unit area is achieved on the at least one growth substrate when using a smaller spacer substrate compared to a larger spacer substrate.

39. The system of claim 38, wherein a size of the at least one spacer substrate is based on a dimension as measured along a radial or longitudinal direction of the at least one spacer substrate.

40. The system of claim 39, wherein the cell growth density per unit area on the at least one growth substrate increases as the dimension of the at least one spacer substrate is reduced along the radial or longitudinal direction.

41. The system of claim 39, wherein the cell growth density per unit area on the at least one growth substrate increases by at least 5% when the size of the at least one spacer substrate is increased by at least 10%.

42. The system of claim 38, wherein the smaller spacer substrate has a smaller surface area than the larger spacer substrate.

43. The system of claim 38, wherein the smaller spacer substrate has a same thickness as the larger spacer substrate.

44. The system of claim 39, wherein a size of the at least one growth substrate is substantially equal to or greater than a size of the at least one spacer substrate.

45. The system of claim 38, wherein the at least one growth substrate and the at least one spacer substrate comprise a same number of openings per unit area.

46. The system of claim 38, wherein the at least one growth substrate and the at least one spacer substrate each comprises a different number of openings per unit area.

47. A bioreactor comprising:

a container;

a rotatable shaft disposed in the container;

a first growth substrate comprising a growth surface and a second growth substrate comprising a growth surface, the growth surface for growth of a biological material, and the first growth substrate and the second growth substrate being coupled to the rotatable shaft, and

a first spacer substrate disposed between the first growth substrate and the second growth substrate.

48. The bioreactor of claim 47, the container configured to retain a growth medium.

49. The bioreactor of claim 47 or claim 48, the growth surface being substantially planar.

50. The bioreactor of any one of claims 47 to 49, each of the first growth substrate and the second growth substrate comprising a mesh.

51. The bioreactor of claim 50, the mesh being formed from a plurality of wires.

52. The bioreactor of claim 51, each wire of the plurality of wires having a thickness of 10 μm to 5,000 μm.

53. The bioreactor of claim 51 or claim 52, adjacent wires of the plurality of wires being separated by a distance of 1 μm to 5,000 μm.

54. The bioreactor of any one of claims 47 to 50, each of the first growth substrate and the second growth substrate being porous.

55. The bioreactor of claim 54, the first growth substrate and the second growth substrate having a porosity of 0.001 to 0.999.

56. The bioreactor of any one of claims 47 to 55, the first growth substrate being disposed 1 μm to 5,000 μm from the first spacer substrate.

57. The bioreactor of any one of claims 47 to 56, comprising a plurality of growth substrates and a plurality of spacer substrates, the plurality of growth substrates being arranged substantially parallel to the plurality of spacer substrates.

58. The bioreactor of any one of claims 47 to 57, the biological material comprising cells, tissues, organs, cell-based meat, cell-based fat, or a combination thereof.

59. The bioreactor of any one of claims 47 to 58, the rotatable shaft being coupled to the first growth substrate and the second substrate.

60. The bioreactor of claim 59, the rotatable shaft being coupled to a lateral center of the first growth substrate and to a lateral center of the second growth substrate.

61. The bioreactor of any one of claims 47 to 60, further comprising a motor coupled to the rotatable shaft to rotate the rotatable shaft, thereby rotating the first growth substrate and the second growth substrate.

62. The bioreactor of claim 61, the motor comprising a servomotor or a stepper motor.

CLAIMS

What is claimed is:

1. A cell cultivation system comprising:

at least one growth substrate for growing one or more cell types, wherein the at least one growth substrate has a mesh porosity and a surface area, and wherein cell growth density per unit area of the at least one growth substrate increases with: 1) increasing mesh porosity of the at least one growth substrate, or 2) decreasing surface area per unit area of the at least one growth substrate.

2. The system of claim 1, wherein the mesh porosity and the surface area per unit area are based on a number of openings in the at least one growth substrate, and wherein the openings are arranged in a repeating pattern across a surface of the at least one growth substrate.

3. The system of claim 2, wherein the cell growth density per unit area on the at least one growth substrate increases with the number of openings by at least 5% when the number of openings is increased by at least 10%.

4. The system of claim 1, wherein the cell growth density per unit area on the at least one growth substrate increases by at least 5% when the surface area per unit area is decreased by at least 10%.

5. The system of claim 1, further comprising at least one spacer substrate adjacent to the at least one growth substrate, wherein the at least one spacer substrate is used to facilitate transport and distribution of a growth medium over or across a surface of the at least one growth substrate.

6. A cell cultivation system comprising:

at least one growth substrate for growing one or more cell types; and

at least one spacer substrate adjacent to the at least one growth substrate, wherein the at least one spacer substrate is sized to influence a cell growth density per unit area on the at least one growth substrate such that a higher cell growth density per unit area is achieved on the at least one growth substrate when using a smaller spacer substrate as compared to a larger spacer substrate.

7. The system of claim 6, wherein a size of the at least one spacer substrate is based on a dimension as measured along a radial or longitudinal direction of the at least one spacer substrate, and wherein the cell growth density per unit area on the at least one growth substrate increases as the dimension of the at least one spacer substrate is reduced along the radial or longitudinal direction.

8. The system of claim 6, wherein the cell growth density per unit area on the at least one growth substrate increases by at least 5% when the size of the at least one spacer substrate is increased by at least 10%.

9. The system of claim 6, wherein the smaller spacer substrate has a smaller surface area than the larger spacer substrate, and wherein the smaller spacer substrate has a same thickness as the larger spacer substrate.

10. The system of claim 6, wherein a size of the at least one growth substrate is substantially equal to or greater than a size of the at least one spacer substrate.

11. The system of claim 6, wherein the at least one growth substrate and the at least one spacer substrate comprise a same number of openings per unit area.

12. The system of claim 6, wherein the at least one growth substrate and the at least one spacer substrate each comprise a different number of openings per unit area.

13. A bioreactor comprising:

a container configured to retain a growth medium;

a rotatable shaft disposed in the container;

a first growth substrate and a second growth substrate , wherein the first growth substrate and the second growth substrate are coupled to the rotatable shaft and configured to grow a biological material; and

a first spacer substrate disposed between the first growth substrate and the second growth substrate.

14. The bioreactor of claim 13, wherein a growth surface on the first growth substrate or second growth substrate is substantially planar.

15. The bioreactor of claim 13, wherein each of the first growth substrate and the second growth substrate comprise a mesh formed from a plurality of wires.

16. The bioreactor of claim 15, wherein adjacent wires of the plurality of wires are separated by a distance of 1 μm to 5,000 μm.

17. The bioreactor of claim 13, wherein the first growth substrate and the second growth substrate are porous and have a porosity of 0.001 to 0.999.

18. The bioreactor of claim 13, wherein the first growth substrate is disposed 1 μm to 5,000 μm from the first spacer substrate.

19. The bioreactor of claim 13, further comprising a plurality of growth substrates and a plurality of spacer substrates, wherein the plurality of growth substrates are arranged substantially parallel to the plurality of spacer substrates.

20. The bioreactor of claim 13, wherein the biological material comprises cells, tissues, organs, cell-based meat, cell-based fat, or a combination thereof.

21. The bioreactor of claim 13, wherein the rotatable shaft is coupled to a lateral center of the first growth substrate and to a lateral center of the second growth substrate.

22. The bioreactor of claim 19, wherein a ratio of an area of the plurality of growth substrates to an area of the plurality of spacer substrates is 1000:1 to 1:1.

23. The bioreactor of claim 19, wherein the plurality of growth substrates have an average pore size greater than an average pore size of the plurality of spacer substrates.

24. The bioreactor of claim 19, wherein the container comprises a hermetically sealable container.

25. The bioreactor of claim 19, wherein the plurality of growth substrates are formed from a first material, and wherein the plurality of spacer substrates are formed from a second material, the first material being different than the second material.

26. The bioreactor of claim 13, wherein the growth substrates comprise a coating that selectively adheres to the cells, wherein the coating comprises a cell-adhesive protein, a cell-adhesive peptide, a coating derived from an animal cell extracellular matrix, collagen, fibronectin, laminin, poly-L-lysine, poly-D-lysine, a coating derived from a plant, arginine-glycine-aspartic acid (RGD)-containing vitronectin-like protein, or a combination thereof.