CLAIMS

1. A system for negative pressure ventilation of an organ comprising:
an actuator configured to cause a first fluid to be displaced by a first volume;
a diaphragm enclosure housing a flexible membrane, the flexible membrane having two surfaces, one of the two surfaces fluidically coupled with the first fluid, another of the two surfaces fluidically coupled to a reservoir chamber via valves, the reservoir chamber containing a second fluid, the flexible membrane displacing the second fluid by the first volume as controlled by the valves when the actuator causes the first fluid to be displaced; and
an organ enclosure housing the organ, the organ enclosure being fluidically coupled with the diaphragm enclosure, the organ enclosure receiving the second fluid from the diaphragm enclosure when the actuator causes the first fluid to be displaced,
wherein displacement of the second fluid enables the negative pressure ventilation and inhalation/exhalation of air by the organ.

2. The system as in claim 1 further comprising:
at least one sensor configured to collect sensor data.

3. The system as in claim 2 wherein the at least one sensor comprises:
a tidal volume sensor configured to collect tidal volume sensor data during the negative pressure ventilation; and
a pressure sensor configured to sense pressure of the second fluid during the negative pressure ventilation.

4. The system as in claim 2 wherein the at least one sensor comprises:
a bubble sensor configured to collect bubble sensor data during a priming process.

5. The system as in claim 2 further comprising:
at least one controller configured to execute instructions, the instructions configured to control devices in the system.

6. The system as in claim 5 wherein the instructions comprise:
receiving the sensor data; and
controlling the actuator based at least on the sensor data.

7. The system as in claim 5 further comprising:
a reservoir holding the second fluid, the reservoir being fluidically coupled with the diaphragm enclosure.

8. The system as in claim 7 wherein the instructions comprise:
receiving bubble sensor data from a bubble sensor, the bubble sensor being fluidically coupled with the reservoir and the organ enclosure; and
moving an amount of the second fluid from the reservoir to the organ enclosure, the amount being based on the bubble sensor data.

9. The system as in claim 7 further comprising:
a perfusion system including:
at least one perfusion pump; and
a gas management system including an enclosure configured to expose venous fluid to gas;
a thermal management system including a device configured to expose the venous fluid exiting the gas management system to a thermal adjustment means;
a perfusate reservoir including a fluid enclosure configured to hold perfusate and receive the venous fluid from the organ, the venous fluid mixing with the perfusate forming a mixed fluid, the perfusate reservoir including a drain configured to discharge excess of the venous fluid and/or the mixed fluid;
a fluid path extending between the perfusion pump, the organ and the perfusate reservoir;
at least one venous fluid sample port; and
at least one arterial fluid sample port.

10. The system as in claim 9 further comprising:
a fluid path including:
at least one venous sensor configured to determine characteristics of the venous fluid; and
at least one arterial sensor configured to determine characteristics of arterial fluid,
wherein the instructions include controlling the perfusion pump, the gas management system, and the thermal management system, the instructions configured to instruct the perfusion pump to pump the venous fluid from the organ through the gas management system and the thermal management system and into the organ.

11. The system as in claim 9 wherein the perfusion system comprises:
at least one venous sensor.

12. The system as in claim 9 wherein the perfusion system comprises:
at least one arterial sensor.

13. The system as in claim 9 wherein the perfusate comprises:
a blood-based fluid.

14. The system as in claim 9 wherein the perfusate comprises:

oxygen-carrying molecules.

15. The system as in claim 1 further comprising:

a portable enclosure enclosing the actuator, the flexible membrane, and the organ enclosure; and a portable power supply.

16. The system as in claim 9 further comprising:

a portable enclosure enclosing the actuator, the flexible membrane, the organ enclosure, and the perfusion system; and

a portable power supply.

17. A method for ventilating an organ using negative pressure ventilation, the method being executed by the system of claim 1, the method comprising:

displacing, by an actuated pump, a first fluid by a first volume, the first fluid being fluidically coupled with a first surface of a flexible membrane that has two surfaces, the flexible membrane housed in a diaphragm enclosure, the diaphragm enclosure being fluidically coupled with an organ enclosure, the flexible membrane displacing a second fluid by the first volume when the first fluid is displaced, the second fluid being contained in a reservoir chamber that is fluidically coupled with another surface of the flexible membrane via valves, the second fluid moving into and out of the organ enclosure causing the organ to expand and contract, forcing air into and out of the organ.

18. The method as in claim 17 further comprising:

sensing tidal volume of the air.

19. The method as in claim 17 further comprising:

pumping perfusate out of the organ;

collecting data associated with the perfusate;

adjusting characteristics of the perfusate based at least on the collected data forming adjusted perfusate; and

pumping the adjusted perfusate into the organ.

20. The method as in claim 19 further comprising:

forming mixed fluid by mixing fresh perfusate with the adjusted perfusate based on the collected data.

21. The method as in claim 19 further comprising:

draining the adjusted perfusate based on the collected data.

22. The method as in claim 17 further comprising:
filtering the air.

23. The method as in claim 17 further comprising:
perfusing the organ normothermically.

24. The method as in claim 17 further comprising:
perfusing the organ non-normothermically.

25. The method as in claim 17 further comprising:
assessing characteristics of the organ during negative pressure ventilation; and
perfusing and/or ventilating medications into the organ based on the characteristics.

26. The system as in claim 1 further comprising:
displacing, by an actuated pump, a first fluid by a first volume, the first fluid being fluidically coupled with a first surface of a flexible membrane, the flexible membrane housed in a diaphragm enclosure, the diaphragm enclosure being fluidically coupled with the organ enclosure and a reservoir, the flexible membrane displacing a second fluid by the first volume when the first fluid is displaced, the second fluid being fluidically coupled with a second surface of the flexible membrane, the second fluid moving from the reservoir to the organ enclosure;
detecting, by a sensor, when the organ enclosure is full; and
closing fluidic coupling between the reservoir and the organ enclosure when the organ enclosure is full.

27. The system as in claim 1 wherein the second fluid comprises:
media formulated to support organ tissue.

28. The system as in claim 1 wherein the second fluid comprises:
sterile fluid.

29. The system as in claim 1 wherein the second fluid comprises:
isotonic fluid.

30. The system as in claim 1 wherein the second fluid comprises:
water-based fluid.

31. The system as in claim 1 wherein the second fluid comprises:
mineral-based hydraulic fluid.

32. The system as in claim 1 further comprising:
a valve controlling movement of the second fluid to/from the organ enclosure.

33. The system as in claim 9 wherein the instructions comprise:
maintaining dissolved gas concentration in the venous fluid at a pre-selected level.

34. The system as in claim 9 wherein the instructions comprise:
maintaining dissolved gas concentration in the venous fluid at a user-entered level.

35. The system as in claim 9 wherein the instructions comprise:
maintaining dissolved gas concentration in the venous fluid at a dynamically-determined level.

36. The system as in claim 9 wherein the devices comprise:
a valve controlling flow to/from the reservoir and the organ enclosure;
the at least one sensor;
the actuator;
the gas management system providing gas to the venous fluid; and
a perfusion pump moving the venous fluid from a venous cavity in the organ to an arterial cavity in the organ.

37. The system as in claim 9 wherein the instructions comprise:
maintaining dissolved gas concentration in the perfusate at a pre-selected level.

38. The system as in claim 9 wherein the instructions comprise:
dynamically modifying ventilation and perfusion parameters based at least on data from the at least one sensor.

39. The system as in claim 9 wherein the instructions comprise:
dynamically modifying characteristics of the perfusate, the venous fluid, and the second fluid based at least on data from the at least one sensor; and
assessing a condition of the organ, the venous fluid, and the perfusate based at least on data from the at least one sensor.

40. The system as in claim 9 wherein the instructions comprise:

computing measurements by measuring a pressure in the organ enclosure, a stroke of the actuator, and characteristics of the air; and

controlling conditions of the negative pressure ventilation based on the measurements.

41. The system as in claim 9 wherein the instructions comprise:

controlling perfusion of the mixed fluid and characteristics of the perfusate based at least on a flowrate of the perfusate and the mixed fluid, a pressure of the perfusate and the mixed fluid at an arterial cavity, temperature of the perfusate and the mixed fluid, and chemical composition of the perfusate and the mixed fluid.

42. The system as in claim 9 wherein the instructions comprise:

assessing the perfusate and the mixed fluid; and

automatically adjusting gas balance of the perfusate and the mixed fluid based at least on the assessment, the adjusting based on a balance of gases provided to the gas management system, the balance being based at least on the assessment.

43. The system as in claim 9 wherein the instructions comprise:

assessing compliance of the organ based at least on tidal volume and pressure of the organ.

44. The system as in claim 9 wherein the instructions comprise:

assessing compliance of the organ based at least on oxygen flux.

45. The system as in claim 9 wherein the instructions comprise:

adjusting a delivery pressure and a fill pressure independently to manage a flow rate of the perfusate and the mixed fluid to achieve a desired pressure of the perfusate and the mixed fluid.

46. The system as in claim 9 wherein the instructions comprise:

adjusting a flow rate and a flow pressure of the perfusate and the mixed fluid as it enters the organ.

47. The system as in claim 9 wherein the instructions comprise:

measuring a resistance in the organ; and

adjusting a flow rate and a flow pressure of the perfusate and the mixed fluid as it enters the organ based on the resistance.

48. The system as in claim 9 wherein the perfusate comprises:

a perfusate fluid including growth media to both grow and challenge an organ.

49. The system as in claim 9 wherein the thermal management system comprises:

maintaining a temperature of the venous fluid and the mixed fluid in a pre-selected temperature range.

50. The system as in claim 9 further comprising:

a perfusate exchange system enabling replacement of the perfusate with a replacement solution.

51. The system as in claim 9 further comprising:

a filter between the at least one perfusion pump and the perfusate reservoir, the filter trapping particulates.

52. The system as in claim 9 wherein the organ enclosure comprises:

four sides and a lid.

53. The system as in claim 9 wherein the organ enclosure comprises:

a cylinder and a lid.

54. The system as in claim 9 wherein the organ enclosure comprises:

transparent sides.

55. The system as in claim 9 wherein the organ enclosure comprises:

a transparent lid.

56. The system as in claim 9 wherein the organ enclosure comprises:

a platform for placing the organ.

57. The system as in claim 9 wherein the organ enclosure comprises:

a platform for placing the organ; and

a mounting plate operably coupled with the platform.

58. The system as in claim 9 wherein the organ enclosure comprises:

at least one interface enabling fluid exchange.

59. The system as in claim 7 wherein the instructions comprise:

opening and closing valves enabling coupled filling and draining of the reservoir and the organ enclosure.

60. The system as in claim 5 wherein the diaphragm enclosure comprises:

at least one exterior shell.

61. The system as in claim 1 wherein the second fluid comprises:
proteins.

62. The system as in claim 1 wherein the second fluid comprises:
clotting factors.

63. The system as in claim 57 wherein the mounting plate comprises:
at least one tubing cavities configured to enable perfusion and ventilation of the organ.

64. The method as in claim 17 wherein the second fluid comprises:
media formulated to support organ tissue.

65. The method as in claim 17 wherein the second fluid comprises:
sterile fluid.

66. The method as in claim 17 wherein the second fluid comprises:
isotonic fluid.

67. The method as in claim 17 wherein the second fluid comprises:
water-based fluid.

68. The method as in claim 17 wherein the second fluid comprises:
mineral-based hydraulic fluid.

69. The method as in claim 17 further comprising:
controlling, by a valve, movement of the second fluid to/from the organ enclosure.

70. The method as in claim 17 further comprising:
maintaining dissolved gas concentration in a venous fluid at a pre-selected level.

71. The method as in claim 17 further comprising:
maintaining dissolved gas concentration in a venous fluid at a user-entered level.

72. The method as in claim 17 further comprising:
maintaining dissolved gas concentration in a venous fluid at a dynamically-determined level.

73. The method as in claim 17 further comprising:
controlling, by a valve, flow to/from a reservoir and the organ enclosure, the reservoir being fluidly coupled with the diaphragm enclosure;
providing, by a gas management system, gas to a venous fluid; and
moving, by a perfusion pump, the venous fluid from a venous cavity in the organ to an arterial cavity in the organ.

74. The method as in claim 17 further comprising:
maintaining dissolved gas concentration in a perfusate at a pre-selected level.

75. The method as in claim 17 further comprising:
dynamically modifying ventilation parameters and perfusion parameters based at least on data from at least one sensor.

76. The method as in claim 75 further comprising:
dynamically modifying characteristics of a perfusate, a venous fluid, and the second fluid based at least on data from the at least one sensor; and
assessing a condition of the organ, the venous fluid, and the perfusate based at least on data from the at least one sensor.

77. The method as in claim 17 further comprising:
computing measurements by measuring a pressure in the organ enclosure, a stroke of an actuator, and characteristics of the air; and
controlling conditions of the negative pressure ventilation based on the measurements.

78. The method as in claim 20 further comprising:
controlling perfusion of the mixed fluid and characteristics of the perfusate based at least on a flowrate of the perfusate and the mixed fluid, a pressure of the perfusate and the mixed fluid at an arterial cavity, temperature of the perfusate and the mixed fluid, and chemical composition of the perfusate and the mixed fluid.

79. The method as in claim 20 further comprising:
assessing the perfusate and the mixed fluid; and
automatically adjusting gas balance of the perfusate and the mixed fluid based at least on the assessment, the adjusting based on a balance of gases provided to the gas management system, the balance being based at least on the assessment.

80. The method as in claim 17 further comprising:

assessing compliance of the organ based at least on tidal volume and pressure of the organ.

81. The method as in claim 17 further comprising:

assessing compliance of the organ based at least on oxygen flux.

82. The method as in claim 20 further comprising:

adjusting a delivery pressure and a fill pressure independently to manage a flow rate of the perfusate and the mixed fluid to achieve a desired pressure of the perfusate and the mixed fluid.

83. The method as in claim 20 further comprising:

adjusting a flow rate and a flow pressure of the perfusate and the mixed fluid as it enters the organ.

84. The method as in claim 20 further comprising:

measuring a resistance in the organ; and

adjusting a flow rate and a flow pressure of the perfusate and the mixed fluid as it enters the organ based on the resistance.

85. The method as in claim 76 wherein the perfusate comprises:

a perfusate fluid including growth media to both grow and challenge an organ.

86. The method as in claim 20 further comprising

maintaining a temperature of a venous fluid and the mixed fluid in a pre-selected temperature range.

87. The method as in claim 76 further comprising:

enabling, by a perfusate exchange system, replacement of the perfusate with a replacement solution.

88. The method as in claim 17 further comprising:

trapping, by a filter, particulates between at least one perfusion pump and a perfusate reservoir.

89. The method as in claim 17 wherein the organ enclosure comprises:

four sides and a lid.

90. The method as in claim 17 wherein the organ enclosure comprises:

a cylinder and a lid.

91. The method as in claim 17 wherein the organ enclosure comprises:
transparent sides.

92. The method as in claim 17 wherein the organ enclosure comprises:
a transparent lid.

93. The method as in claim 17 wherein the organ enclosure comprises:
a platform for placing the organ.

94. The method as in claim 17 wherein the organ enclosure comprises:
a platform for placing the organ; and
a mounting plate operably coupled with the platform.

95. The method as in claim 17 wherein the organ enclosure comprises:
at least one interface enabling fluid exchange.

96. The method as in claim 17 further comprising:
opening and closing valves enabling coupled filling and draining of a reservoir and the organ enclosure.

97. The method as in claim 17 wherein the diaphragm enclosure comprises:
at least one exterior shell.

98. The method as in claim 17 wherein the second fluid comprises:
proteins.

99. The method as in claim 17 wherein the second fluid comprises:
clotting factors.

100. The method as in claim 94 wherein the mounting plate comprises:
at least one tubing cavities configured to enable perfusion and ventilation of the organ.