CLAIMS

1. A cell culture apparatus comprising:

(a) a bioreactor vessel configured to receive liquid media;

(b) a first filtration assembly in fluid communication with the bioreactor vessel, wherein the first filtration assembly comprises:

(i) a first filtration system;

(ii) a first harvest pump connected in series with the first filtration system, wherein the first harvest pump is configured to pump the liquid media from the bioreactor vessel through the first filtration system; and

(iii) a sensor, wherein the sensor is configured to interact with the liquid media inside the first filtration assembly; and

(c) a second filtration assembly configured to operate in parallel with the first filtration assembly, wherein the second filtration assembly is in fluid communication with the bioreactor vessel, and wherein the second filtration assembly comprises:

(i) a second filtration system; and

(ii) a second harvest pump connected in series with the second filtration system, wherein the second harvest pump is configured to pump the liquid media from the bioreactor vessel through the second filtration system; and

(d) a controller, wherein the controller executes operations comprising:

(i) receiving, from the sensor, information indicative of an operable state of the first filtration system;

(ii) determining, based on at least the received information from the sensor, whether the first filtration system is in an operable state; and

(iii) responsive to a determination that the first filtration system is not in an operable state, causing the first harvest pump to stop pumping liquid media through the first filtration system.

2. The cell culture apparatus of claim 1, wherein at least one of the first filtration system and the second filtration system comprises a tangential flow filter or an alternating tangential flow filter.

3. The cell culture apparatus of claim 1, wherein each of the first filtration system and the second filtration system comprise a filter membrane having a pore size of 0.1 micron to 1 micron.

4. The cell culture apparatus of claim 1, wherein the sensor comprises a pressure sensor, and wherein determining that the first filtration system is not in an operable state comprises determining that a pressure in the first filtration assembly is greater than a threshold value.

5. The cell culture apparatus of claim 1, wherein the sensor comprises a capacitance or optical sensor.

6. The cell culture apparatus of claim 1, wherein the sensor is configured to monitor cell density or flow rate.

7. The cell culture apparatus of claim 1, wherein the sensor is a Raman sensor or a Fourier transform infrared (FTIR) sensor.

8. The cell culture apparatus of claim 1, wherein the controller is further configured to:

responsive to the determination that the first filtration system is not in an operable state, cause the second harvest pump to increase a flow rate of liquid media through the second filtration system.

9 The cell culture apparatus of claim 8, wherein causing the second harvest pump to increase the flow of liquid media through the second filtration system comprises approximately doubling the flow rate.

10. The cell culture apparatus of claim 1, wherein the controller is further configured to:

responsive to the determination that the first filtration system is not in an operable state, output a notification.

11. The cell culture apparatus of claim 10, wherein the notification comprises a visual alert or an auditory alert.

12. The cell culture apparatus of claim 1, further comprising an isolation valve connected in series with the first filtration assembly, wherein the valve is configured to control the flow of liquid media through the first filtration assembly, and wherein the controller is further configured to:

responsive to the determination that the first filtration system is not in an operable state, close the isolation valve.

13. The cell culture apparatus of claim 1, wherein the first filtration assembly further comprises a guard filter connected in series with the first filtration system, wherein the guard filter is connected downstream of the first filtration system and the sensor.

14. The cell culture apparatus of claim 13, wherein the guard filter has a pore size of 0.1 micron to 1 micron.

15. The cell culture apparatus of claim 1, further comprising a capture operation configured to collect product from the liquid media, wherein the capture operation is in fluid communication with the bioreactor vessel by way of at least the first filtration assembly, wherein the capture operation comprises a multi-column chromatography (MCC).

16. A method of culturing cells, the method comprising:

(a) at least partially filling a bioreactor vessel with cells and liquid media, wherein the bioreactor vessel is in fluid communication with a first filtration system and a second filtration system connected in parallel with the first filtration system;

(b) pumping liquid media from the bioreactor vessel through the first filtration system using a first harvest pump, wherein the first harvest pump is connected in series with the first filtration system;

(c) pumping liquid media from the bioreactor vessel through the second filtration system using a second harvest pump, wherein the second harvest pump is connected in series with the second filtration system;

(d) receiving, from a sensor configured to interact with the liquid media, information indicative of an operational state of the first filtration system;

(e) determining, based on at least the received information from the sensor, whether the first filtration system is in an operable state; and

(f) responsive to a determination that the first filtration system is not in an operable state, causing the first harvest pump to stop pumping liquid media through the first filtration system.

17. The method of claim 16, wherein at least one of the first filtration system and the second filtration system comprises an alternating tangential flow filter.

18. The method of claim 16, wherein the sensor comprises a pressure sensor.

19. The method of claim 18, wherein the received information comprises information relating to a pressure of liquid media downstream of the first filtration

system.

20. The method of claim 18, wherein the received information comprises information relating to a transmembrane pressure across the first filtration system.

21. The method of claim 18, wherein determining whether the first filtration system is in an operable state comprises determining that a pressure of the liquid media is above a predetermined threshold value.

22. The method of claim 16, wherein pumping liquid media from the bioreactor vessel through the first filtration system comprises pumping liquid media at a first flow rate, wherein pumping liquid media from the bioreactor vessel through the second filtration system comprises pumping liquid media at a second flow rate, and wherein the first flow rate is approximately equal to the second flow rate.

23. The method of claim 16, further comprising:

responsive to the determination that the first filtration system is not in an operable state, causing the second harvest pump to increase a flow rate of liquid media through the second filtration system.

24. The method of claim 23, wherein causing the second harvest pump to increase a flow rate of liquid media through the second filtration system comprises approximately doubling the flow rate of liquid media through the second filtration system.

25. The method of claim 16, further comprising:

responsive to a determination that the first filtration system is not in an operable state, outputting a notification.