WHAT IS CLAIMED IS:

1. A method comprising:

a) performing a first continuous culture of cells in a chamber of at least one first bioreactor under culture conditions that produce cell growth;

b) during the first continuous culture, moving culture fluid comprising cells from the chamber of the at least one first bioreactor into a chamber of at least one second bioreactor though one or more fluidic conduits that put the chamber of the at least one first bioreactor in fluidic communication with the chamber of the at least one second bioreactor; and

c) performing, in the chamber of the at least one second bioreactor, a second continuous culture of cells moved from the at least one first bioreactor, under culture conditions that produce at least one culture product;

wherein the rate of cell growth in the first continuous culture is greater than that of the second continuous culture, and the production of culture product in the first continuous culture is less than that of the second continuous culture.

2. The method of claim **1**, further comprising:

d) collecting the at least one culture product from the chamber of the at least one second bioreactor.

3. The method of claim **1** or **2**, wherein:

(i) the rate of cell growth in the first continuous culture is at least twice that of the second continuous culture, and the production of culture product in the second continuous culture is at least twice that of first continuous culture;

(ii)

the rate of cell growth in the first continuous culture is at least 10 times that of the second continuous culture, and the production of culture product in the second continuous culture is at least 10 times that of first continuous culture; or

(iii)

the rate of cell growth in the first continuous culture is at least 100 times that of the second continuous culture, and the production of culture product in the second continuous culture is at least 100 times that of first continuous culture.

4. The method of any one of claims **1** to **3**, wherein the rate of cell growth in the first continuous culture is at least 80%, or at least 90%, of the maximum growth rate.

5. The method of any one of claims **1** to **4**, wherein the production of culture product in the second continuous culture is at least 80%, or at least 90%, of the optimal culture product production rate.

6. The method of any one of claims **1** to **5**, comprising maintaining cell density in the at least one first bioreactor.

7. The method of any one of claims **1** to **6**, wherein performing the first continuous culture further comprises maintaining constant volume of the culture of cells in the chamber of the at least one first bioreactor.

8. The method of claim **7**, wherein maintaining volume comprises moving the culture fluid comprising media and cells from the chamber of the at least one first bioreactor to the chamber of the at least one second bioreactor when the volume of the first continuous culture exceeds the target volume.

9. The method of any one of claims **1** to **8**, comprising growing the cells in the chamber of the at least one first bioreactor at a constant cell growth rate.

10. The method of any one of claims **1** to **9**, wherein:

(i) no nutrient in the first continuous culture is growth limiting; or

(ii)

at least one nutrient, e.g., carbon or phosphorus, in the first continuous culture is at growth limiting concentration.

11. The method of any one of claims **1** to **10**, wherein the rate of culture product production per unit volume in first continuous cell culture is less than any of 50%, 40%, 30%, 20%, 10%, 5%, 3%, or 1% that of the second continuous culture.

12. The method of any one of claims **1** to **11**, wherein cells are moved from the chamber of the at least one first bioreactor during log-phase growth.

13. The method of any one of claims **1** to **12**, wherein culture fluid comprising cells is moved from the chamber of the at least one first bioreactor into a chamber of the at least one second bioreactor continuously over a period of at least any of one minute, five minutes, 10 minutes, 30 minutes, one hour, three hours, six hours, 12 hours, one day, two days, four days, one week, two weeks, one month, two months, three months, four months, five months, six months, seven months, eight months, nine months, ten months, eleven months or twelve months.

14. The method of any one of claims **1** to **13**, wherein culture fluid comprising cells is moved from the chamber of the at least one first bioreactor into a chamber of the at least one second bioreactor when the optical density (O.D.) of the first continuous culture reaches at least any of 1, 5, 10, 25, 50, 100, 200, and 400.

15. The method of any one of claims **1** to **14**, wherein the growth rate of cells in the second continuous culture is no more than any of 50%, 40%, 30%, 20%, 10%, 5%, 3%, or 1% that of the first continuous culture or the maximum growth rate of the cells under non-limiting culture conditions.

16. The method of any one of claims **1** to **15**, wherein cells in the second continuous cell culture are not growing.

17. The method of any one of claims **1** to **16**, wherein at least one nutrient in the second continuous culture is present at a growth rate limiting concentration.

18. The method of any one of claims **1** to **17**, wherein the culture conditions of the second continuous culture comprise a growth limiting concentration of one or more nutrients, a vitamin, a salt, phosphate, sulfate, chloride, acetate, citrate and other anionic salt, magnesium, calcium, sodium, potassium, ammonium and other cationic salt, boric acid, choline, ascorbic acid, lipoic acid, nicotinic acid, inositol, amino acids, nucleic acid bases, or complex nutrients.

19. The method of any one of claims **1 to 18**, comprising performing the second continuous culture in a plurality of different second bioreactors.

20. The method of any one of claims **1** to **19**, wherein the at least one first bioreactor is a plurality of first bioreactors.

21. The method of any one of claims **1** to **20**, wherein the culture conditions of the second continuous culture are different than culture conditions of the first continuous culture.

22. The method of any one of claims **1 to 21**, comprising inducing activity of a biochemical pathway that produces a culture output in the second continuous culture but not in the first continuous culture.

23. The method of any one of claims **1 to 22**, wherein cells removed from the chamber of the at least one second bioreactor are recycled into that chamber with a cell recycling device such as a hollow fiber filter.

24. The method of any one of claims **1** to **23**, wherein performing either first or second continuous culture comprises providing one or more of: a metal, a vitamin , a

contamination control agent such as an antibiotic or biocide, an inducer, a salt, phosphate, sulfate, chloride, acetate, citrate and other anionic salt, magnesium, calcium, sodium, potassium, ammonium and other cationic salt, boric acid, choline, ascorbic acid, lipoic acid, nicotinic acid, inositol, antifoaming agents, amino acids, nucleic acid bases, complex nutrients, a macro-nutrient, a micro-nutrient, a cell growth factor, a carbon source, or a nitrogen source.

25. The method of any one of claims **1** to **24**, wherein performing either first or second continuous culture comprises regulating one or more of: a nitrogen sparing rate, an aeration rate, an oxygen sparging rate, a carbon dioxide sparing rate, culture agitation speed, concentration of CO_2, concentration of carbon source, concentration of nitrogen source, concentration of metals, vitamins, salts and concentration of an antibiotic.

26. The method of any one of claims **1 to 25**, wherein collecting the at least one culture product comprises removing cell culture fluid from the chamber of the at least one second bioreactor, and separating cells from the cell culture fluid to produce a cell free broth.

27. The method of any one of claims **1** to **26**, wherein a culture product is selected from a polypeptide, an organic molecule that is the product of a synthetic pathway in the cell; a flagrance, an amino acid, an organic acid; an alcohol; and a fatty acid.

28. The method of any one of claims **1** to **27**, wherein the cells comprise archaea, prokaryotes and/or eukaryotes.

29. The method of any one of claims **1** to **28**, wherein the cells comprise fungal cells, bacterial cells, insect cells, animal cells plant cells or a cell line.

30. A system comprising:

(a) at least one first bioreactor comprising:

(i) a first chamber; and

(ii) one or more first sensors providing at least a measure of cell density and a measure of volume of a cell culture in the first chamber;

(b) at least one second bioreactor comprising:

(i) a second chamber; and

(ii) one or more second sensors providing at least a measure of culture conditions and a measure of volume of a cell culture in the one or more second chambers;

wherein the first chamber is in fluidic communication with the one or more second chambers;

(c) one or more reagent reservoirs comprising liquid reagents, wherein the reagent reservoirs are in fluidic communication with the first chamber and, optionally, with the one or more second chambers;

(d) one or more pumps configured to:

(i) move liquid reagents from at least one reagent reservoir to the first chamber;

(ii) move cell culture fluid from the first chamber to the one or more second chambers;

(iii) move cell culture fluid out of the one or more second chambers;

(iv) optionally move liquid reagents from at least one reagent reservoir to the one or more second chambers; and

(e) a control system configured to:

(i) use measures from the one or more sensors to control cell growth, e.g., cell density, of a culture of cells in the first chamber at a rate greater than that of the second chamber;

(ii) move cell culture fluid from the first chamber to the one or more second chambers; and

(iii) use measures from the one or more sensors to control culture conditions and, e.g., volume and/or cell growth, of a culture of cells in the one or more second chambers to produce a culture product at a rate greater than that of the first chamber.

31. The method of claim **30**, wherein the control system uses measures from the one or more sensors to establish a rate of cell growth in the first continuous culture is at least twice, at least 10 times or at least 100 times that of the second continuous culture, and a rate of production of culture product in the second continuous culture is at least twice, at least 10 times or at least 100 times that of first continuous culture.

32. The system of claim **30** or **31**, wherein the control system that controls volume of a cell culture in the first chamber or the one or more second chambers comprises a level sensor (*e.g.*, an overflow tube) that moves cell culture fluid from a chamber when the height of the cell culture exceeds the top of the level sensor.

33. The system of any one of claims **30** to **32**, wherein the control system comprises a computer comprising a processor and memory comprising executable code which, when executed by the processor, performs one or more feedback routines to control the cell growth, e.g., cell density, in the first chamber, control volume of a cell culture in the first chamber and/or one or more second chambers, and control the culture conditions in the one or more second chambers control.

34. The system of claim **32**, wherein:

(I) the one or more sensors provide measures of one or more culture parameters in the first and/or one or more second chambers;

(II) the system further comprises one or more effectors to affect changes in the one or more culture parameters;

(III) one or more one of the feedback routines calculate one or more culture parameters based on the measures, and actuate the one or more effectors to adjust the culture parameters toward target levels.

35. The system of claim **32**, wherein:

(I) the one or more sensors provide measures of one or more of pH, temperature and dissolved O_2 of a cell culture in the first and/or second one or more chambers;

(II) the system further comprises one or more of:

one or more reagent reservoirs comprising an acid and a base in fluid communication with the first and/or one or more second reservoirs;

one or more temperature controllers to control temperature of a cell culture in the first and/or one or more second chambers;

one or more aerators for aerating a cell culture in the first chamber and/or one or more second chambers;

(III) one or more one of the feedback routines calculate a culture condition comprising one or more of pH, temperature, dissolved O_2, and nutrient concentration based on a measure received from the one or more sensors, and actuates:

one or more pumps to move acid or base from the reagent reservoir into the second chamber, to adjust pH to a target pH;

one or more temperature controllers to adjust temperature to a target temperature; and/or

one or more aerators to aerate the cell culture to a target dissolved oxygen level.

36. The system of claim **32**, wherein one feedback routine calculates the volume of a cell culture in the one or more second chambers based on a measure received from the one or more sensors, and, if the volume is above a set point, actuates a pump to move liquid cell culture from the one or more second chambers.

37. The system of any one of claims **30** to **36**, further comprising a filter in fluid communication with an exit of the second chamber, configured to recycle cells that cannot pass

through a membrane back into the second chamber, and passes cell-depleted liquid culture medium out of the cartridge to a collection vessel.

38. The system of any one of claims **30** to **37**, wherein the first chamber comprises a cell culture, and wherein the one or more reagent reservoirs in fluidic communication with the first chamber comprise growth medium in which one or more nutrients are present at a concentration that limits growth rate of the cells in the cell culture.

39. The system of any one of claims **30** to **38**, wherein the one or more control subsystems comprise a computer comprising:

(A) a processor;

(B) a memory coupled to the processor, and

(C) computer executable instructions that use measures from the one or sensors to calculate culture conditions in the first chamber and/or one or more second chambers, based on the calculations, control the pumps to move liquids to and from the chambers.

40. The system of any one of claims **30** to **39**, comprising one or more of:

- a temperature sensor and a temperature regulator;
- a dissolved oxygen meter and an aeration system communicating with an interior of the first and/or one or more second chambers;
- an analyzer for measuring concentration of a nutrient in a cell culture in a chamber;
- an impeller or a pneumatic agitator to mix liquid in a chamber, and a motor configured to actuate the impeller or pneumatic agitator;
- an effluent communicating with the vessel interior and a regulatable valve or pump for regulating fluid flow from the chamber;
- baffles in the chamber;
- a sparger and mass flow controller communicating with the chamber interior for input of one or more gases and mixtures thereof;
- a user interface for communicating instructions with the computer;
- a foam control;
- a cell recycling hollow fiber membrane; and
- a reverse or forward osmosis membrane.

41. The system of any one of claims **30** to **41**, wherein the control system is configured to carry out any of the methods of claims **1-29**.

42. A method comprising:

a) performing a first continuous culture of cells in a chamber of a first bioreactor under culture conditions that maintain a constant cell density;

b) during the first continuous culture, moving culture fluid comprising cells from the chamber of the first bioreactor into a chamber of at least one second bioreactor though one or more fluidic conduits that put the chamber of the first bioreactor in fluidic communication with the chamber of the at least one second bioreactor;

c) performing a second continuous culture of cells moved from the first bioreactor in the chamber of each of the one or more second bioreactors under constant culture conditions, to produce at least one culture product; and

d) collecting the at least one culture product from the chamber of each of the one or more second bioreactors.

43. A system comprising:

(a) a first bioreactor comprising:

(i) a first chamber; and

(ii) one or more first sensors providing at least a measure of cell density and a measure of volume of a cell culture in the first chamber;

(b) one or more second bioreactors comprising:

(i) a second chamber; and

(ii) one or more second sensors providing at least a measure of culture conditions and a measure of volume of a cell culture in the one or more second chambers;

wherein the first chamber is in fluidic communication with the one or more second chambers;

(c) one or more reagent reservoirs comprising liquid reagents, wherein the reagent reservoirs are in fluidic communication with the first chamber and, optionally, with the one or more second chambers;

(d) one or more pumps configured to:

(i) move liquid reagents from at least one reagent reservoir to the first chamber;

(ii) move cell culture fluid from the first chamber to the one or more second chambers;

(iii) move cell culture fluid out of the one or more second chambers;

(iv) optionally move liquid reagents from at least one reagent reservoir to the one or more second chambers; and

(e) a control system configured to:

(i) use measures from the one or more sensors to control cell growth, e.g., cell density, of a culture of cells in the first chamber;

(ii) move cell culture fluid from the first chamber to the one or more second chambers; and

(iii) use measures from the one or more sensors to control culture conditions and, e.g., volume and/or cell growth, of a culture of cells in the one or more second chambers.