Batch and Continuous Culture

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Growth

- **Growth may be defined as an increase in cellular constituents.**
- **It** leads to a rise in cell number when microorganisms reproduce by processes like budding or binary fission.
- In the latter, individual cells enlarge and divide to yield two progeny of approximately equal size.
- Growth also results when cells simply become longer or larger.
- If the microorganism is **coenocytic—that is, a multinucleate organism in** which nuclear divisions are not accompanied by cell divisions— growth results in an increase in cell size but not cell number.
- It is usually not convenient to investigate the growth and reproduction of individual microorganisms because of their small size.
- Therefore, when studying growth, microbiologists normally follow changes in the total population number.

Batch Culture

- Population growth is studied by analyzing the growth curve of a microbial culture.
- When microorganisms are cultivated in liquid medium, they usually are grown in a **batch culture or closed system—**that is, they are incubated in a closed culture vessel with a single batch of medium.
- Because no fresh medium is provided during incubation, nutrient concentrations decline and concentrations of wastes increase.
- In a batch culture process, all of the substances are aggregated simultaneously and then undertake interaction without any additional external input.
- It is used in the manufacturing of wines and bread.

Continuous Culture

- It is possible to grow microorganisms in an open system, a system with constant environmental conditions maintained through continual provision of nutrients and removal of wastes.
- These conditions are met in the laboratory by a **continuous culture system.**
- **A microbial** population can be maintained in the exponential growth phase and at a constant biomass concentration for extended periods in a continuous culture system.
- Continuous culture is a method in which components are added as required throughout the process, and the product is eliminated as they are established.
- Because of the constant availability of nutrients, the incredibly exponential phase is generally lengthened in this type.
- Two major types of continuous culture systems commonly are used:
  - (1) chemostats and
  - (2) turbidostats.

Chemostat

- A **chemostat is constructed** so that sterile medium is fed into the culture vessel at the same rate as the media containing microorganisms is removed (**figure 6.9).**
- **The culture medium for a chemostat possesses an essential** nutrient (e.g., an amino acid) in limiting quantities.
- Because of the presence of a limiting nutrient, the growth rate is determined by the rate at which new medium is fed into the growth chamber, and the final cell density depends on the concentration of the limiting nutrient.
- The rate of nutrient exchange is expressed as the dilution rate (D), the rate at which medium flows through the culture vessel relative to the vessel volume, where f is the flow rate (ml/hr) and V is the vessel volume (ml).

$$D = f/V$$

- For example, if f is 30 ml/hr and V is 100 ml, the dilution rate is 0.30 hr^{-1}.

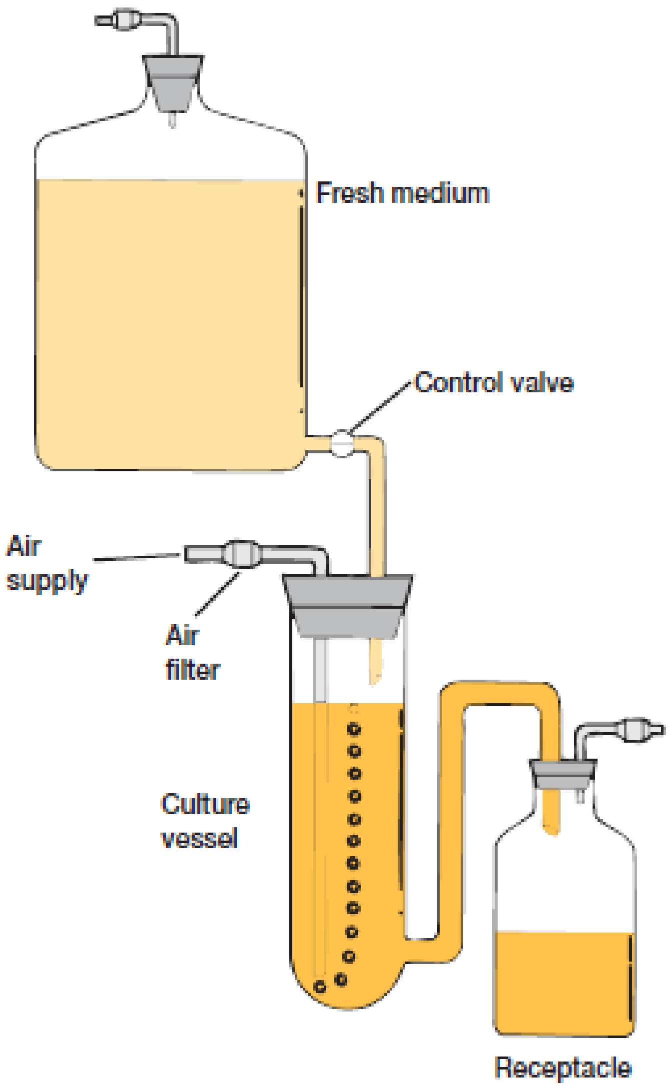

Figure 6.9 A Continuous Culture System: The Chemostat.

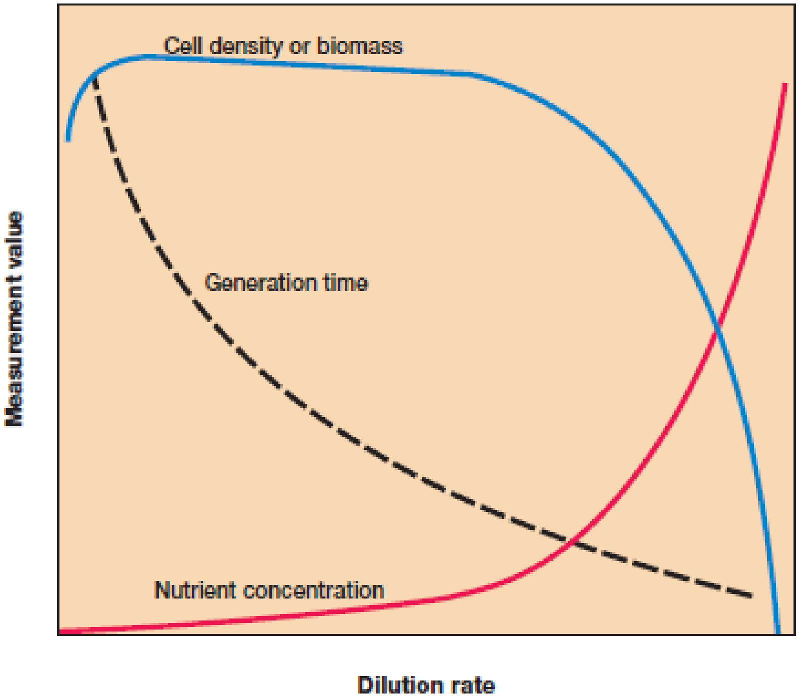

Figure 6.10 Chemostat Dilution Rate and Microbial Growth. The effects of changing the dilution rate in a chemostat.

- Both the microbial population level and the generation time are related to the dilution rate**.**
- **The microbial population** density remains unchanged over a wide range of dilution rates.
- The generation time decreases (i.e., the growth rate rises) as the dilution rate increases.
- The limiting nutrient will be almost completely depleted under these balanced conditions.
- If the dilution rate rises too high, the microorganisms can actually be washed out of the culture vessel before reproducing because the dilution rate is greater than the maximum growth rate.
- The limiting nutrient concentration rises at higher dilution rates because fewer microorganisms are present to use it.

- At very low dilution rates, an increase in *D causes a rise in* both cell density and the growth rate.
- This is because of the effect of nutrient concentration on the growth rate, sometimes called the **Monod relationship**.
- *Only a limited supply of nutrient* is available at low dilution rates.
- Much of the available energy must be used for cell maintenance, not for growth and reproduction.
- As the dilution rate increases, the amount of nutrients and the resulting cell density rise because energy is available for both maintenance and growth.
- The growth rate increases when the total available energy exceeds the **maintenance energy.**

Turbidostat

- The second type of continuous culture system, the **turbidostat,** has a photocell that measures the absorbance or turbidity of the culture in the growth vessel.
- The flow rate of media through the vessel is automatically regulated to maintain a predetermined turbidity or cell density.
- The turbidostat differs from the chemostat in several ways.
  - The dilution rate in a turbidostat varies rather than remaining constant, and its culture medium lacks a limiting nutrient.
  - The turbidostat operates best at high dilution rates; the chemostat is most stable and effective at lower dilution rates.
- Continuous culture systems are very useful because they provide a constant supply of cells in exponential phase and growing at a known rate.
- They make possible the study of microbial growth at very low nutrient levels, concentrations close to those present in natural environments.
- These systems are essential for research in many areas—for example, in studies on interactions between microbial species under environmental conditions resembling those in a freshwater lake or pond.
- Continuous systems also are used in food and industrial microbiology.

What is the difference between batch, fed-batch and continuous fermentation?

In the batch method, extra nutrients are not supplied till the end of the process. In a fed-batch culture, nutrients are added systematically for an extended duration, unlike in a continuous batch where nutrients are added, and products are removed continuously.