

FERMENTATION TECHNOLOGY

Types of Industrial Fermentation Processes



INDUSTRIAL FERMENTATION METHODS

Fermentation: An art from the past, a skill for the future...

Brain McNeil

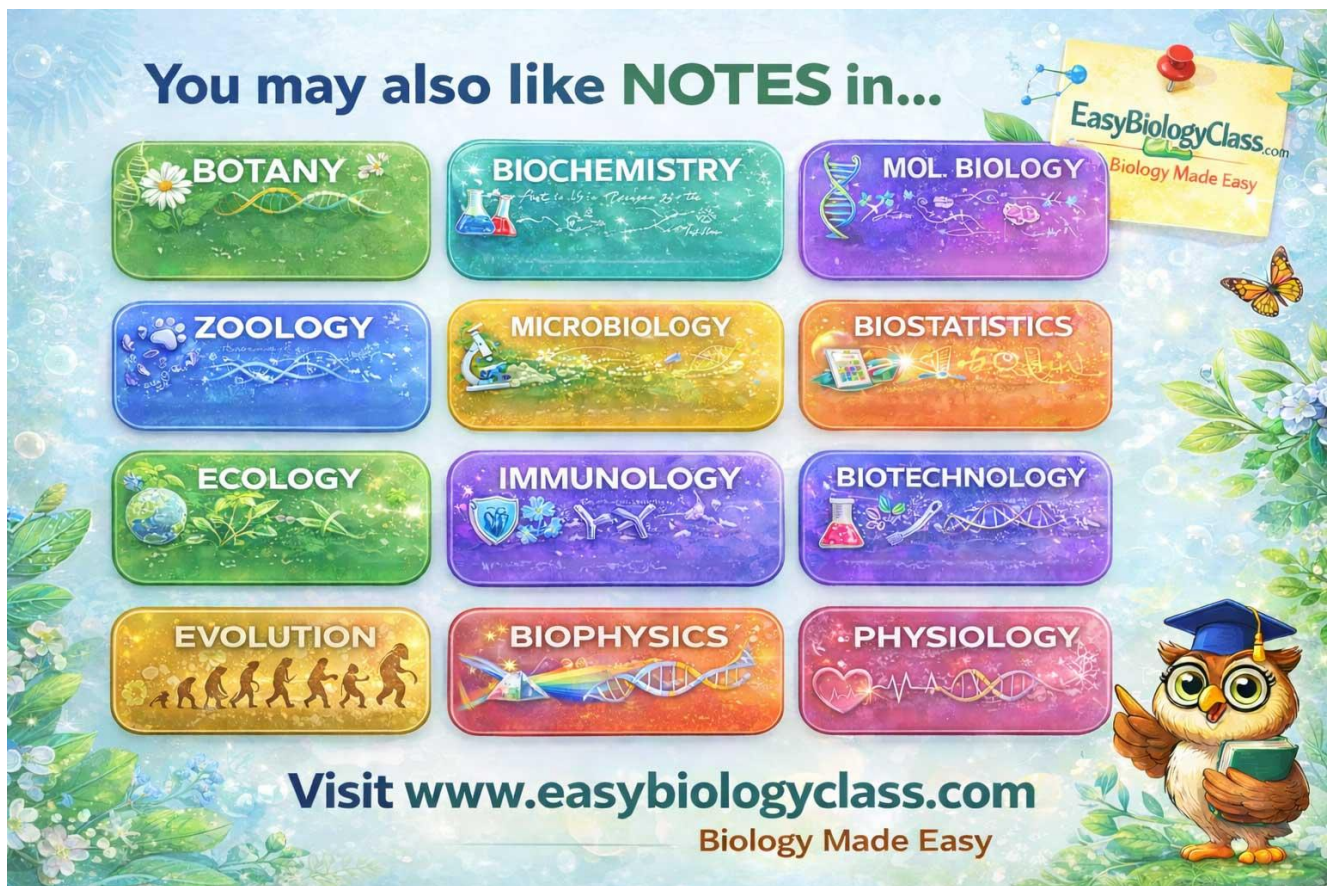
What is fermentation?

- Fermentation is a metabolic process which converts carbohydrates to alcohols, organic acids or gases by the activity of enzymes of microbial origin.
- Microbes involved in fermentation process: Bacteria and Fungi.
- The process of anaerobic respiration in the muscle cells of animals during exercise which produce lactic acid is also a type of fermentation.
- The technique of fermentation was very ancient in origin.
- Egyptians and Sumerians had the knowledge of the technique of converting starchy grains to alcoholics.
- For a microbiologist, the word 'fermentation' means many processes such as:
 - A method of mass cultivation of microbes under aerobic or anaerobic conditions.
 - Any biological process occurs in the absence of oxygen.
 - Spoilage of food by microbial activity.
 - Production of alcoholic beverages, organic acids, antibiotics or biopolymers

- Partial oxidation of carbohydrates

What is industrial fermentation?

- The intentional use of fermentation technology for the large scale production of microbial biomass or metabolites is called industrial fermentation.
- Fermented products have immense use in food, medicine and other industries.
- Modern industrial fermentation units use genetically engineered microbes for the rapid production of desired metabolites.



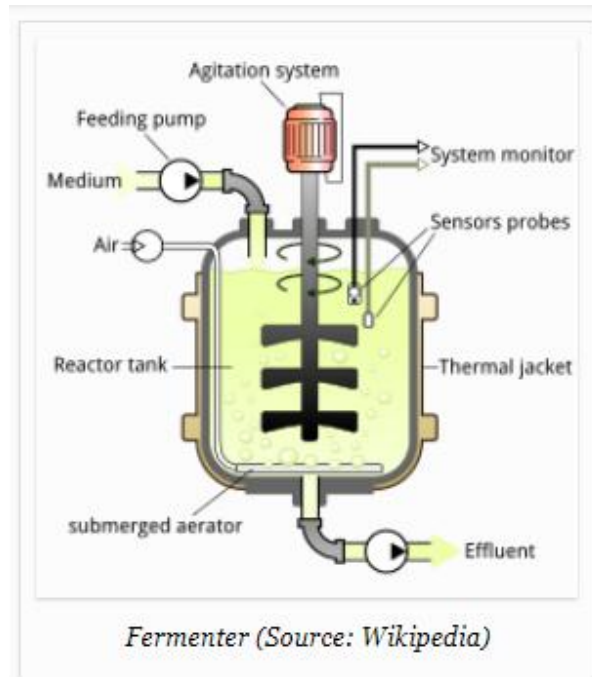
What is a fermenter?

- The heart of industrial fermentation is a 'Fermenter'.
- Fermenter is type of bioreactor*
- Fermenter: a system provided with controlled environmental conditions for the growth of microbes in liquid culture and production of specific metabolites.

- It is a device in which the microbes are cultivated and motivated to form the desired products.
- It is containment system to provide the accurate environment for the optimum growth and metabolic activity of the microbes.
- Fermenter prevents the entry and growth of contaminating microbes from outside.
- Fermenter: containment system for the cultivation of prokaryotic cells (bacteria) and fungi
- Bioreactor: containment system for the cultivation of mammalian or insect cells

What are the main parts of a fermenter and their uses?

- A fermenter possesses the following mechanical parts:
 - A large vessel made of stainless or rust free material.
 - Motors provided with an automatic control system.
 - Heaters with thermostat system for providing and manipulating temperature.
 - Pups for the addition or removal of substances and water to the fermenter.
 - Gas source and pipeline system for aeration.
 - Sensors for pH and aeration.
 - Peripheral manual or automatic controlling facilities.
- The mechanical components of the fermenter proves:
 - A space for taking raw material (culture media / carbon source)



- Provide a contamination free environment for the growth of microbes.
- Maintain optimum temperature in the system.
- Provide adequate mixing and agitation in the medium.
- Provide ample aeration for aerobic fermentation.
- Control and maintain optimum pH condition in the fermenter
- Monitor the concentration of dissolved oxygen in the system
- Allow the addition of nutrients in between the fermentation process (in continuous fermentation)
- Facility for maintaining a wide range of organisms.
- Provision for collecting over-flow from the fermenter (in continuous fermentation)

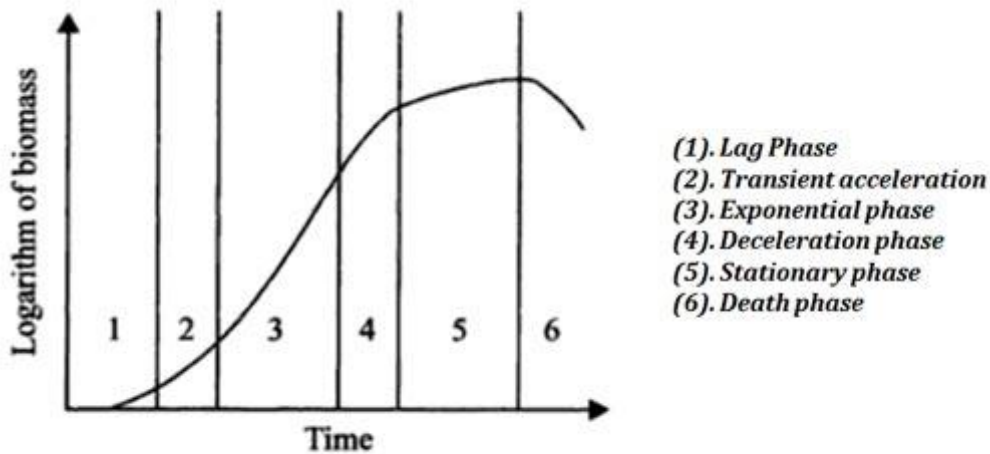
What are the different types of fermentation process / methods?

- There are three types of industrial fermentation processes based on the methods of fermentation and types of fermenters.
 1. Batch fermentation
 2. Continuous fermentation
 3. Fed-batch fermentation

1. Batch Fermentation

- Microorganism is inoculated into a fixed volume of medium.
- As the growth takes place, the nutrients are consumed and the product of growth accumulates in the fermenter.
- Product of growth may be of two types: (a) Biomass and (b). Metabolites.
- The nutrient environment in the fermenter is continuously changed.
- This change in the environment in the fermenter will enforce change in the metabolism of cells.
- This also results in the cessation of cell multiplication.
- Cessation of growth is due to the scarcity of nutrients and accumulation of metabolites.
- Once the microbes reached the stationary phase they start to accumulate the metabolites.
- Metabolites are extracted from the fermenter by downstream processes.
- After the fermentation is over, the residues are taken out from the fermentation tank, and the vessel is then cleaned and sterilized before next batch of fermentation.
- Thus in batch fermentation, the large scale production is done as separates 'batches'.

- Microbes in the batch culture show the following pattern of growth with distinct phases.
 1. Log phase: initial phase, no apparent growth of microbes, they adapt to the environmental conditions.
 2. Transient acceleration: the inoculum begins to grow slowly.
 3. Exponential phase: microbial growth proceeds at the maximum possible rate.
 4. Deceleration phase: decline in the growth rate of microbes
 5. Stationary phase: no overall growth rate (death of the cells equals to the division of cells). Most of the secondary metabolites are produced in this phase.
 6. Death phase: no growth at all, cells starts to die and the population size decreases. Usually the fermentation stops before the death phase.



Characteristic Growth Curve of Microbes in Batch Culture

2. Continuous Fermentation

- Here the exponential growth rate of the microbes is maintained in the fermenter for prolonged periods of time in by the addition of fresh media at regular intervals.
- Microbes reach the exponential growth rate and continue as such due to the availability of nutrients.
- The exponential growth rate of microbes continues till the vessel becomes completely filled in the cells.
- Continuous fermenter possesses devices for the collection of overflow from the vessel.
- The metabolite or the product of fermentation is extracted for the overflow by downstream processing.
- Thus unlike batch fermentation, in continuous fermentation, the fermentation process never stops in between and it continues to run for a long period of time with the addition of nutrients and harvesting the metabolites at regular intervals.

3. Fed-batch fermentation

- It is a modified version of batch fermentation.
- Here the substrate is added in increments at different times throughout the course of fermentation.

- Periodical addition of substrate keeps the prolonged log and stationary phase of the microbes in the fermenter.
- This results in the rapid increase of biomass.
- Consequently increased production of metabolites can be achieved in the stationary phase.
- Thus fed-batch technique is an improved version of fermentation by avoiding the disadvantages of batch and continuous fermentation techniques.

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