MICROBIAL FERMENTATION

Biotechnology Lecture

Ph. D. Students

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AGENDA

- Introduction.
- Fermentation media.
- Industrial microorganisms.
- Types of fermentation.
- Batch fermentation.
- Fed-Batch fermentation.
- Growth rate.
- Continuous fermentation.
- Effect of flow rate on substrate concentration.
- Important factors for continuous fermentation.
- Classification of fermentation.

INTRODUCTION

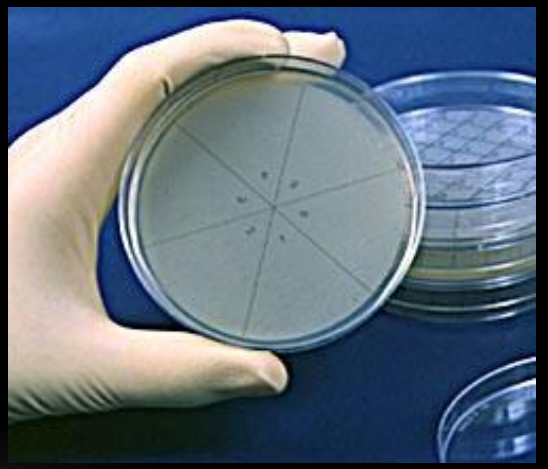
- The fermentation industry is composed of five major bio-ingredient categories.
- They are:
  - Proteins & amino acids.
  - Organic acids.
  - Antibiotics.
  - Enzymes.
  - Vitamins & hormones.

INTRODUCTION (CONT.)

- **Fermentation industry is driven by:**
  - The cost and availability of feed-stocks.
  - The efficiency of industrial microorganism.
  - Fermentation condition and optimization.
  - Down stream process and end-product recovery efficiency.
  - Fermentation by-product utilization.
  - Utility consumption and labor cost.

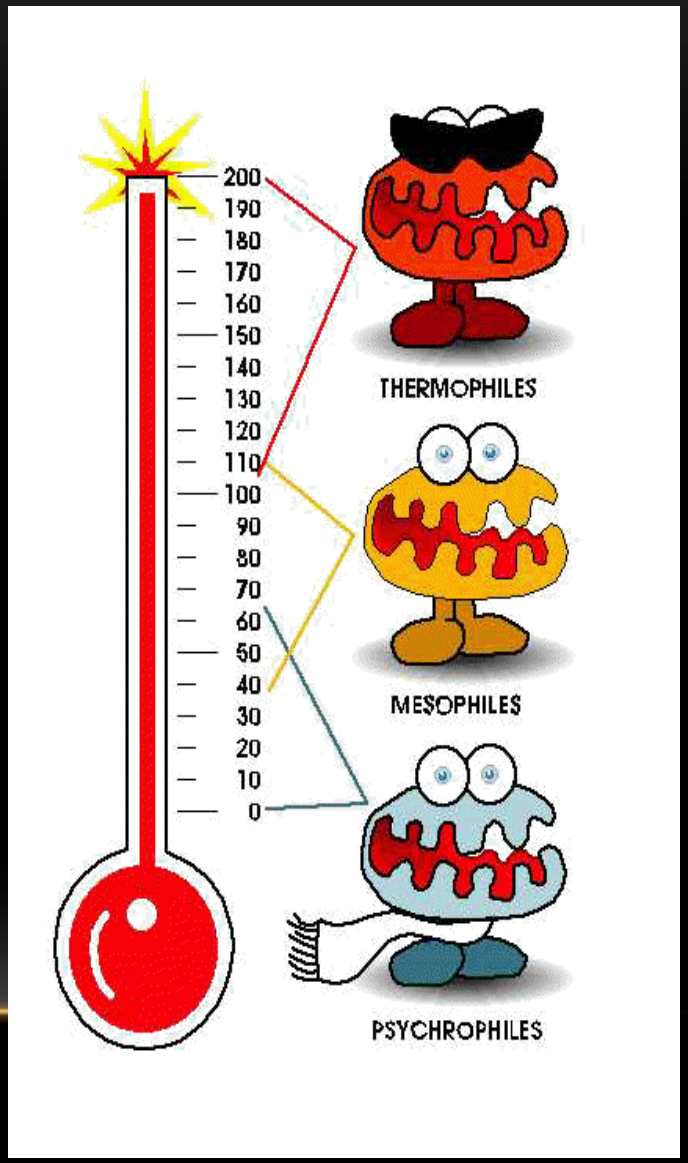
FERMENTATION MEDIA

- Optimum balance of the media is mandatory for cells propagation and for the maximum production of target metabolite (end-product).
- Media compositions:
  - Carbon source.
  - Nitrogen source.
  - Minerals.
  - Growth factors.
  - Precursors (mutants).



INDUSTRIAL MICROORGANISMS

- Microbial screening.
  - Wild strains.
- Microbial yield improvement
  - Mutation.
  - Recombinant DNA.
  - Genetically engineered.
- Microbial selection.
- Industrial microorganism



TYPES OF FERMENTATION

- Solid State fermentation (SSF).
- Liquid State fermentation (LSF) Surface culture & submerged culture

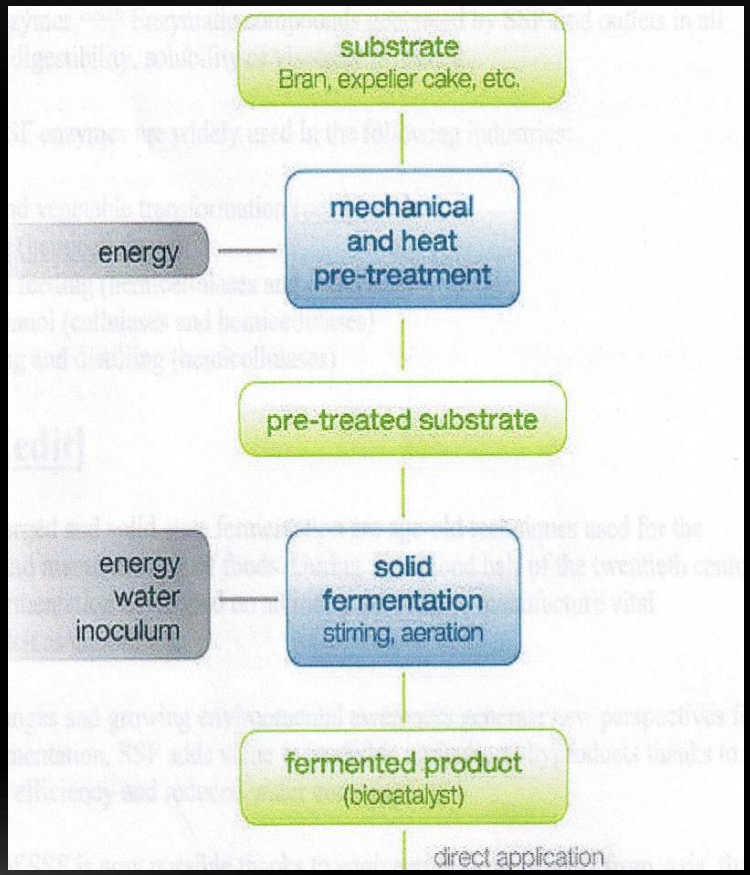
SOLID STATE FERMENTATION (SSF)

- SSF process can be defined as microbial growth on particles without presence of free water.
- Particles are a solid culture substrate such as rice or wheat bran saturated with water and inoculated with (mold, yeast, bacteria) in controlled room temperature.
- It is ideal for growing filamentous fungi.
- It has been used in Asia and developing nations.
- It is more cost effective (smaller vessels lower water consumption, reduced waste water treatment costs, lower energy consumption, and less contamination problems).

SSF PROCESS AND APPLICATIONS

Applications:

- Potentially many high value products such as extra-cellular enzymes, primary metabolites, and antibiotics could be produced in SSF.
- It is estimated that nearly a third of industrial enzyme produced in Japan is made by SSF process.
- Production of organic and ethanol from starchy substrates.
- Digestibility of fibers and lignocelluloses materials for both human and animal consumption.



LIQUID STATE FERMENTATION (LSF) [SUBMERGED CULTURE]

- Submerged culture is performed in tanks which can reach in size for over 100,000 gallons.
- It is ideal for the growing unicellular organisms such as bacteria and yeast.

LSF methods:

- **Batch fermentation.**
- **Fed-batch fermentation.**
- **Continuous fermentation.**
- **Semi-continuous fermentation.**

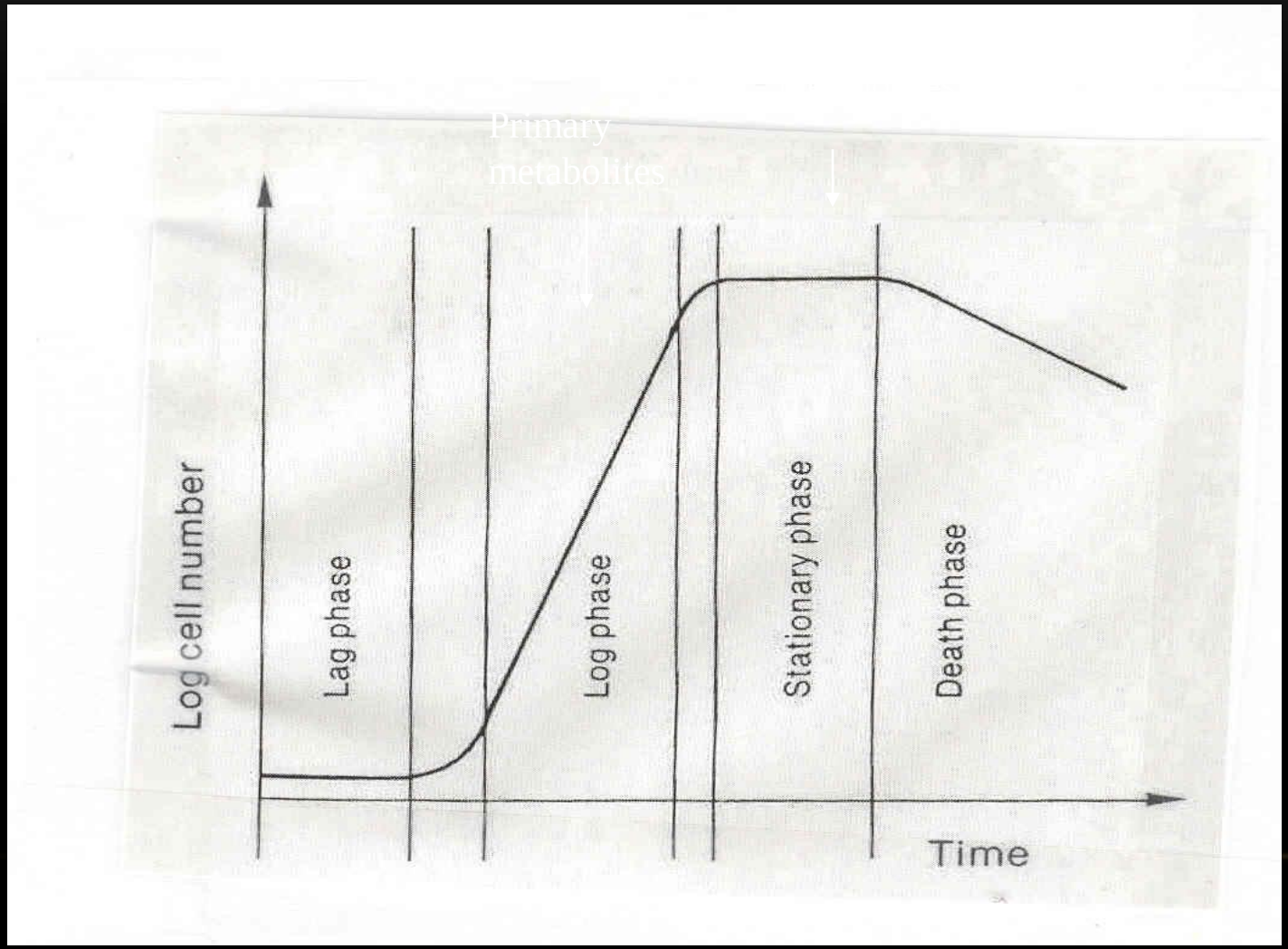
Batch fermentation

- Considered to be a closed system.
- The sterilized media in the fermenter is inoculated with the microorganism.
- Incubation is allowed under the optimum conditions (aeration, agitation, temperature).
- During entire fermentation nothing is added except air, antifoam and acid/base.

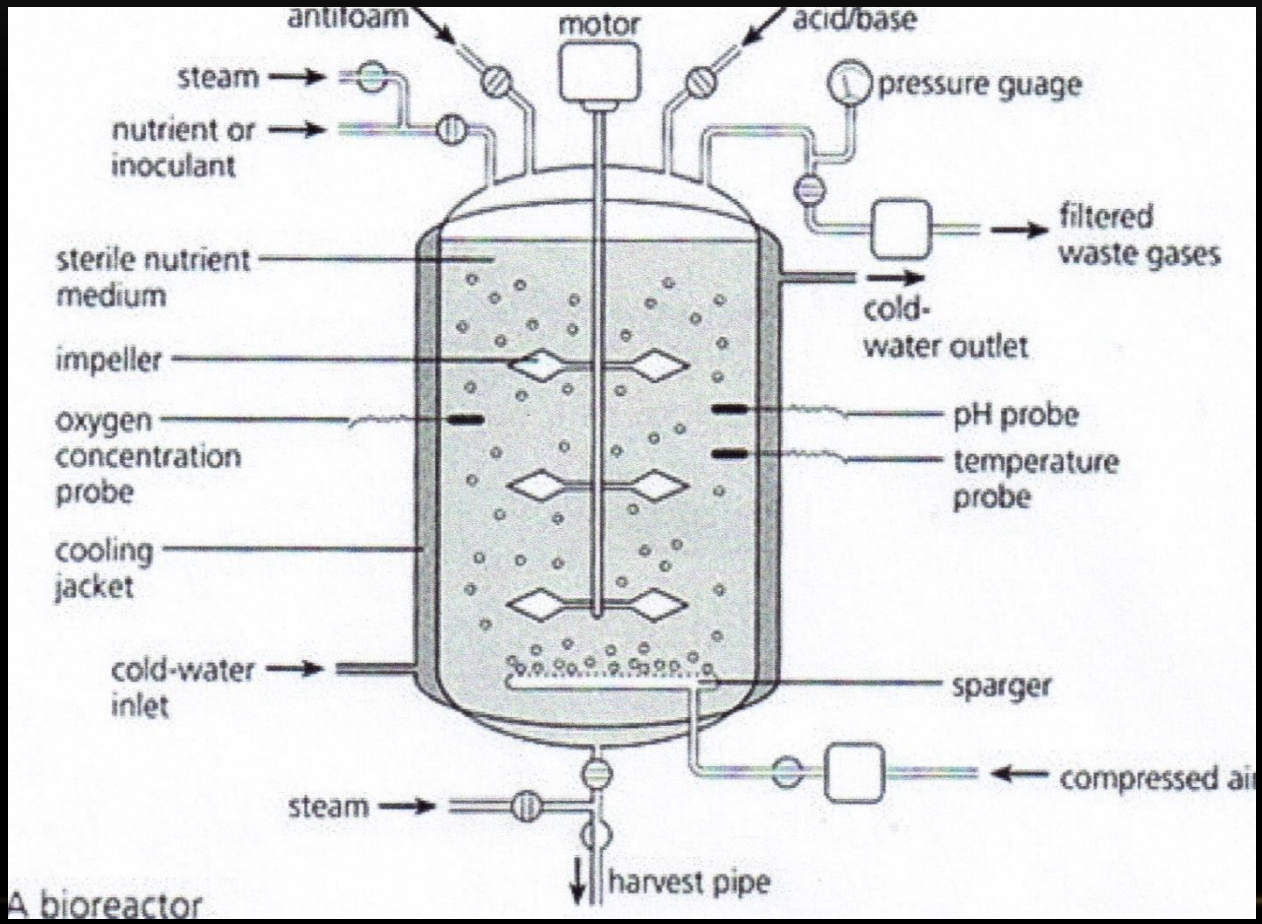
FED-BATCH FERMENTATION

- It is enhancement of batch fermentation.
- Continue adding the nutrients (feeding) in a small doses during the fermentation.
- The method in controlling nutrients feeding process is by measuring methods.
- The main advantage of fed-batch fermentation is the elimination of catabolite repression (feed-back inhibition).

MICROBIAL GROWTH RATE



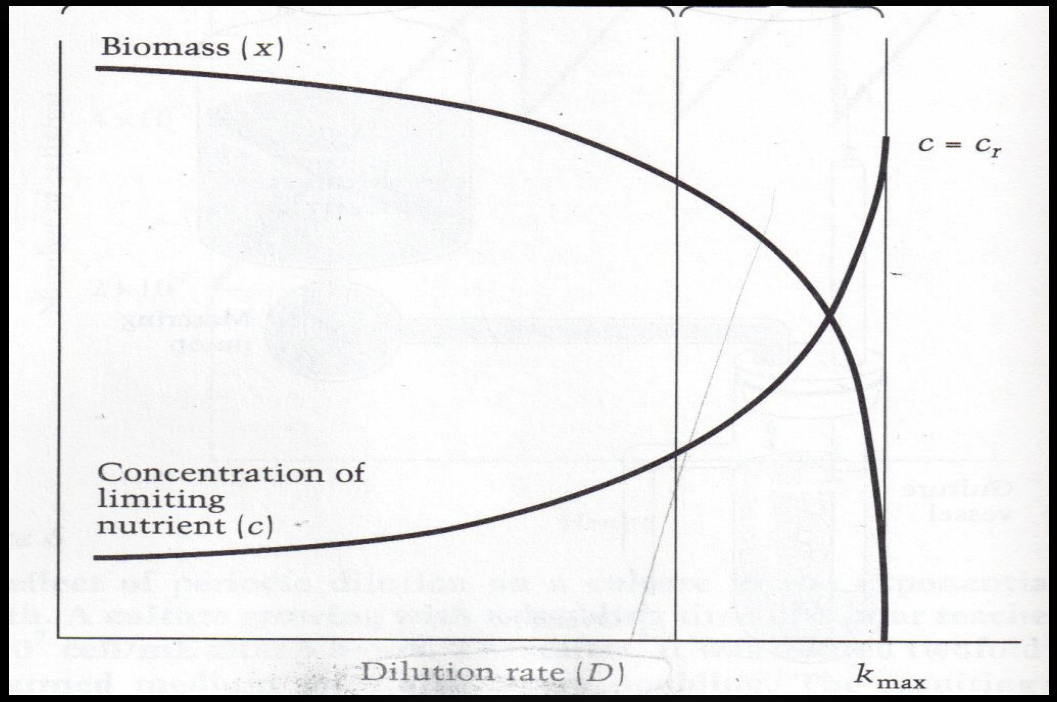
BATCH FERMENTER SYSTEM



CONTINUOUS FERMENTATION

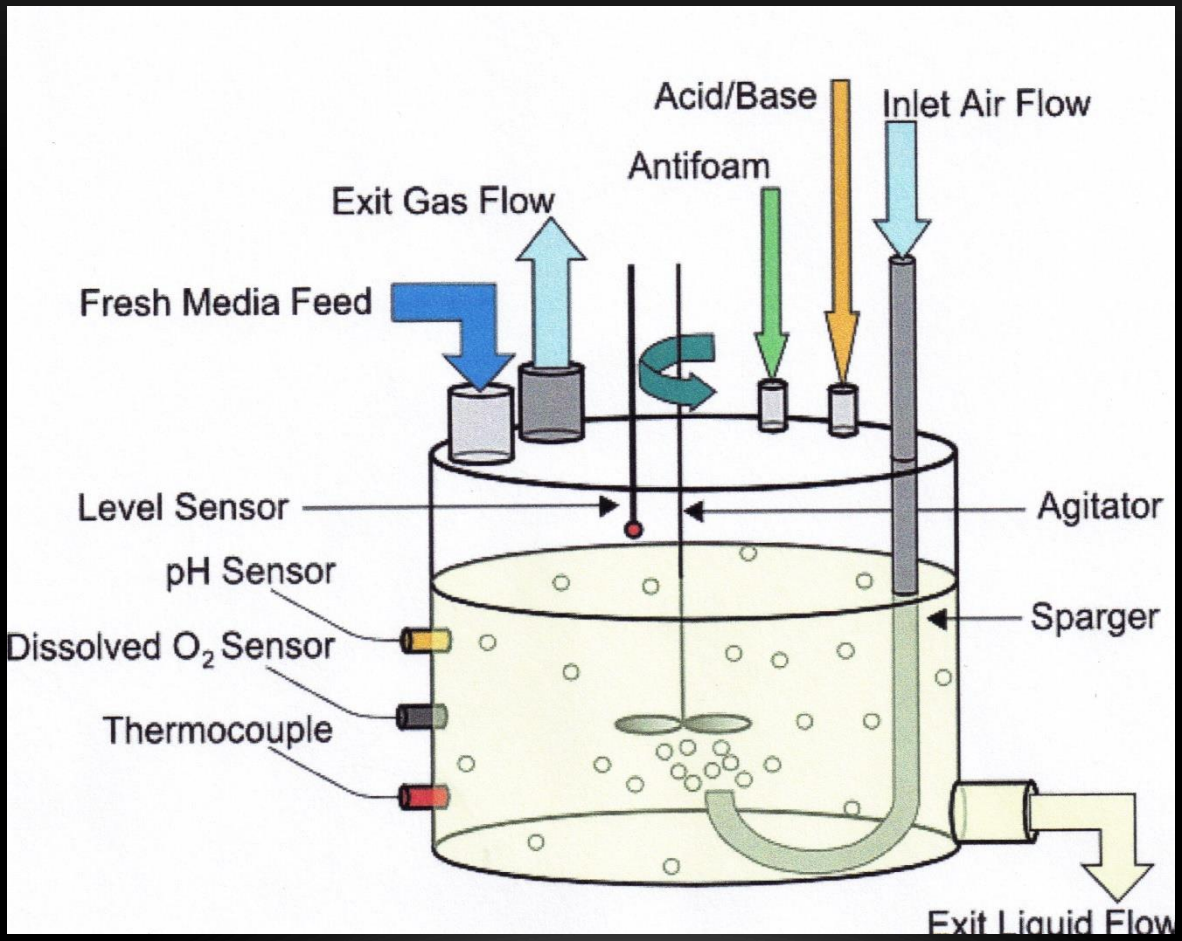
- It is an open system.
- Continuously sterile nutrient is added and the converted nutrient is taken out from the fermentor.
- In continuous process cell loss as a result of outflow must be balanced by growth of the microorganism.

EFFECT OF FLOW RATE ON SUBSTRATE CONCENTRATION



The relationship between biomass (**X**), the concentration of limiting nutrients (**C**) ,and the dilution rate (**D**) are important factors in continuous

CONTINUOUS FERMENTER SYSTEM



IMPORTANT FACTORS FOR CONTINUOUS FERMENTATION

- The system must be stable for at least 500 hours.
- Maintaining sterile conditions for all period of fermentation time.
- The composition of nutrients must be constant all the time.
- Maintaining the strain stability for constant high production yield (concerning about reverse mutation).

SEMI-CONTINUOUS FERMENTATION

- Semi-continuous fermentations, in which a fraction of a fermentation is replaced with fresh media at regular intervals.