FDE 328
INDUSTRIAL MICROBIOLOGY

Instructor:

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To be used in the industrial microbiology field, all microorganisms must satisfy the following characteristics:

1. The industrial microorganism must produce the substance of interest.
2. The microorganism of interest must be obtained in pure culture.
3. Must be genetically stable and, also, amenable to genetic manipulation.
4. Must grow in large-scale cultures.
5. The pure cultures of the microorganism must be maintained for a long period of time in in vitro conditions.
6. The microorganism must be capable of growing vigorously after inoculation into a seedstage vessel.

To be used in the industrial microbiology field, all microorganisms must satisfy the following characteristics:

7. It must produce the desired product in a relatively short period of time.
8. The microorganism must be able to grow in a relatively inexpensive liquid culture medium obtainable in bulk quantities.
9. It must be able to produce a desirable product, preferably a single one that easily recovered and preferably with the absence of any toxic by-products.
10. An industrial microorganism should not be harmful to humans or economically important animals and plants.
11. The microorganism should be capable of protecting itself from contamination (by production of antimicrobial substance) and should not be vulnerable to bacteriophages.
12. The most favorable industrial microorganisms are those of large cell size, as larger cells settle rapidly from a culture or can be easily filtered out with relatively inexpensive filter materials.

Fermentation products

Primary metabolites:

- produced during active growth (the **trophophase**)
- include amino acids, organic acids, vitamins and industrial solvents such as alcohols and acetone

Secondary metabolites:

- produced in the stationary phase after microbial biomass production has peaked (the **idiophase**)
- generally not essential for growth or reproduction
- alkaloids and antibiotics

Fermentation Products

- **Fermentation products**
  - **High volume, low value products**
    (food and beverage fermentation products)
  - **Low volume, high value products**
    (fine chemicals and pharmaceuticals)

Fermentation Products

Food, beverages, food additives and supplements

- Dairy products (yogurt, cheese)
- Alcoholic beverages (beer, wine)
- Amino acids and vitamins

Fermentation Products

Health-care products

- Antibiotics-over 4000 isolated, only 50 used regularly
  - β-lactams, penicillins and cephalosporins
  - Aminoglycosides (e.g. streptomycin)
  - Tetracyclines

- Other important pharmaceutical products
  - alkaloids, steroids and vaccines
  - therapeutic recombinant human proteins such as insulin, interferons and human growth hormone

Fermentation Products

Production of microbial enzymes

- Extracellular hydrolytic enzymes (proteases, carbohydrases)

Industrial chemicals and fuels

- Industrial feedstock chemicals
  - Various alcohols, solvents such as acetone, organic acids, polysaccharides, lipids and raw materials for the production of plastics
- Fuels
  - Methane and ethanol, hydrogen, ethane, propane and butanol

Environmental roles of microorganisms

- Wastewater treatment, desulphurization of fuels, leaching of metals (e.g. copper, iron, uranium and zinc) from low-grade mineral ores and wastes using species of *Thiobacillus* and *Sulfolobus*, use of microorganisms to reduce usage of synthetic pesticides

Fermentation

- The word fermentation from a microbiological perspective is used to describe any biological process occurring under anaerobic conditions (absence of oxygen). However, many researchers use the term to describe any process that uses a microorganism to convert a particular medium into a specific product.

- Two important aspects of microbial growth which are of prime importance in industrial microbiology are;
  - The primary metabolites resulting from the log phase or trophophase.
  - The secondary metabolites resulting from the stationary phase or idiophase.

The Use of the Word «Fermentation» in Industrial Microbiology

- The word fermentation comes from the Latin verb *fevere*, which means to boil. It originated from the fact that early at the start of wine fermentation gas bubbles are released continuously to the surface giving the impression of boiling. It has three different meanings which might be confusing.

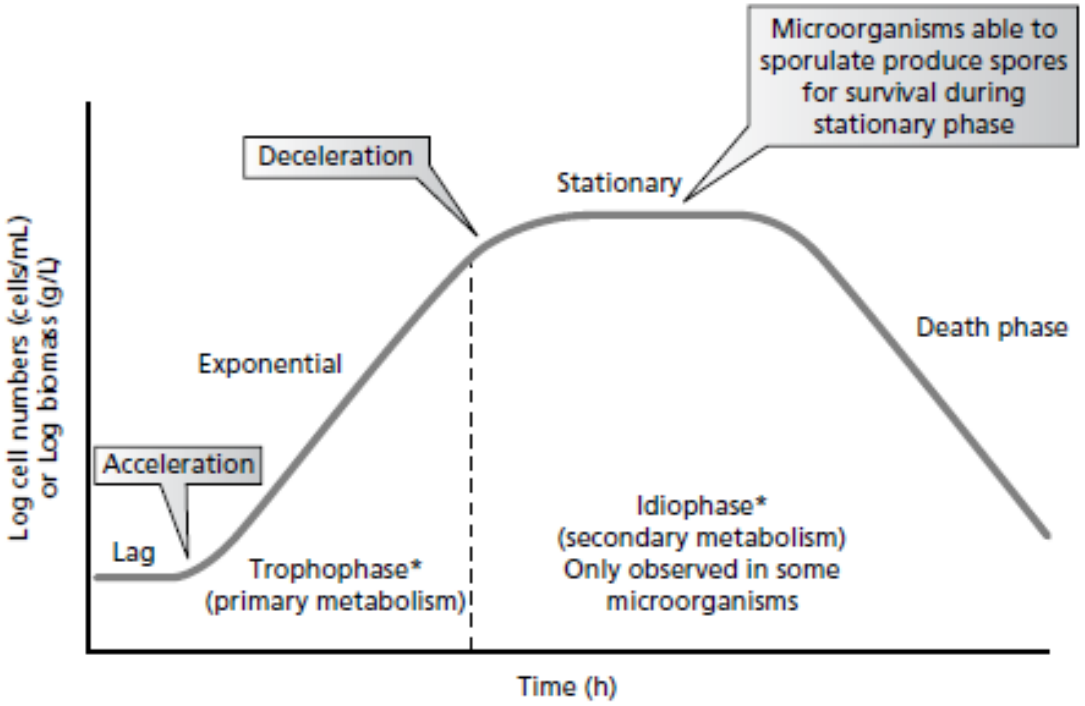
The Use of the Word «Fermentation» in Industrial Microbiology

- The first meaning relates to microbial physiology. In strict physiological terms, fermentation is defined in microbiology as the type of metabolism of a carbon source in which energy is generated by substrate level phosphorylation and in which organic molecules function as the final electron acceptor (or as acceptors of the reducing equivalents) generated during the break-down of carbon-containing compounds or catabolism. As is well-known, when the final acceptor is an inorganic compound the process is called respiration. Respiration is referred to as aerobic if the final acceptor is oxygen and anaerobic when it is some other inorganic compound outside oxygen e.g sulphate or nitrate.

- The second usage of the word is in industrial microbiology, where the term 'fermentation' is any process in which micro-organisms are grown on a large scale, even if the final electron acceptor is not an organic compound (i.e. even if the growth is carried out under aerobic conditions). Thus, the production of penicillin, and the growth of yeast cells which are both highly aerobic, and the production of ethanol or alcoholic beverages which are fermentations in the physiological sense, are all referred to as fermentations.

- The third usage concerns food. A fermented food is one, the processing of which microorganisms play a major part. Microorganisms determine the nature of the food through producing the flavor components as well deciding the general character of the food, but microorganisms form only a small portion of the finished product by weight. Foods such as cheese, bread, and yoghurt are fermented foods.

Fermentation Process



Growth of a microorganism in a batch culture