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# Introduction to Fermentation

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# What is Fermentation?

The term “fermentation” is derived from the Latin verb *fervere,* to boil, thus describing the appearance of the action of yeast on the extracts of fruit or malted grain.

The boiling appearance is due to the production of carbon dioxide bubbles caused by the anaerobic catabolism of the sugar present in the extract.

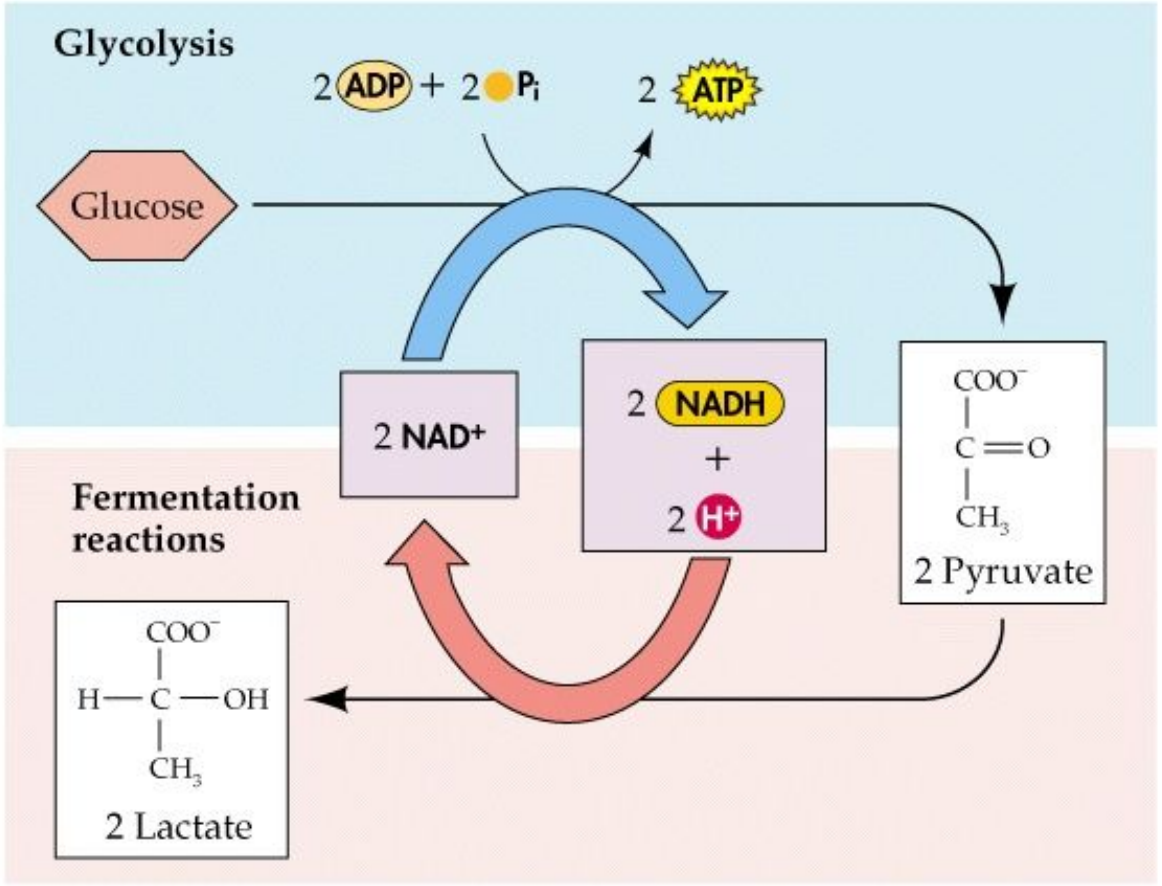
Fermentation is an ancient process and occurs normally in microorganisms that live in the absence of oxygen.

# Fermentation meaning….

- **Biochemical fermentation** is generation of energy by the catabolism of organic compounds.

- **Industrial fermentation** is a chemical engineering term used to describe the processes that utilize a chemical change induced by a living organism or enzyme, in particular bacteria, yeasts, molds, or fungi, that produces a specific product

Fermentation includes the metabolic pathway **glycolysis** (where a single molecule of glucose is broken down into 2 molecules of pyruvate), as well as additional fermentation reactions that produce a variety of end products (acids, alcohols, gases).



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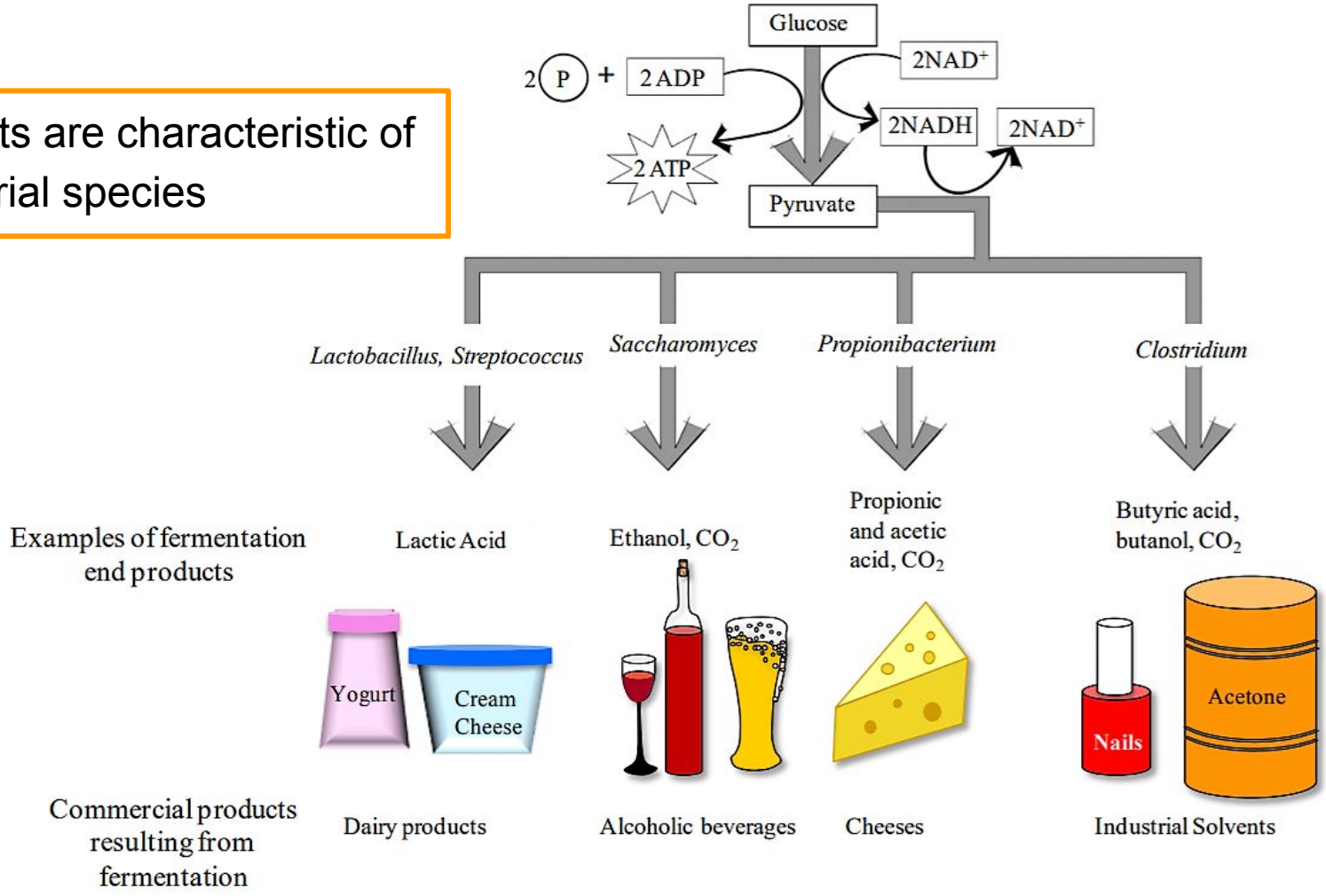
The end products are characteristic of individual bacterial species

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Fermentation is also possible from non-sugar molecules. Even unusual compounds like aromatics (benzoate), glycerol (sugar-alcohol), and acetylene (hydrocarbons) may be fermented by some bacterial species

# THE RANGE OF FERMENTATION PROCESSES

There are five major groups of commercially important fermentations:

1. Those that produce microbial cells (or biomass) as the product.

2. Those that produce microbial enzymes.

3. Those that produce microbial metabolites.

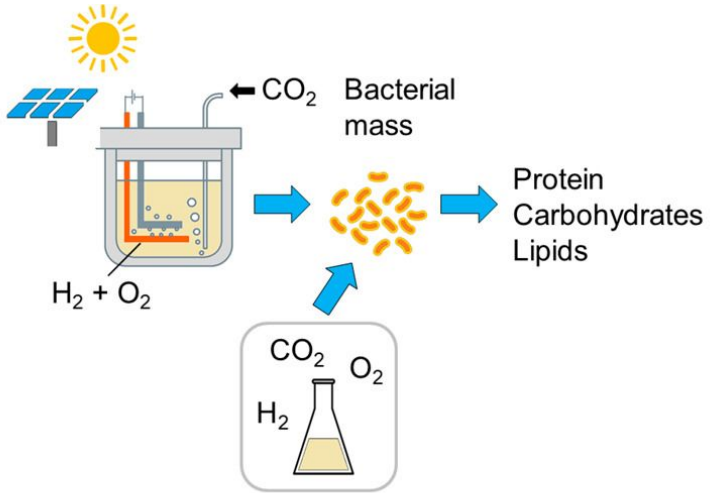
4. Those that produce recombinant products.

5. Those that modify a compound that is added to the fermentation—the transformation process.

# Microbial Biomass

The commercial production of microbial biomass may be divided into two major processes:

- the production of yeast to be used in the baking industry (since 1900)
- the production of microbial cells to be used as human food or animal feed (single-cell protein) (since 1970).



# MICROBIAL ENZYMES

Enzymes have been produced commercially from plant, animal, and microbial sources.

Microbial enzymes have the enormous advantage of being able to be produced in large quantities by established fermentation techniques.

Enzyme production is closely controlled in microorganisms and in order to improve productivity these controls may have to be exploited or modified.

**Table 1.1** Commercial Applications of Enzymes

| Industry | Application | Enzyme | Source |
|---|---|---|---|
| Baking and milling | Reduction of dough viscosity, acceleration of fermentation, increase in loaf volume, improvement of crumb softness, and maintenance of freshness | Amylase | Fungal |
| | Improvement of dough texture, reduction of mixing time, increase in loaf volume | Protease | Fungal/bacterial |
| Brewing | Mashing | Amylase | Fungal/bacterial |
| | Chill proofing | Protease | Fungal/bacterial |
| | Improvement of fine filtration | β-Glucanase | Fungal/bacterial |
| Cereals | Precooked baby foods, breakfast foods | Amylase | Fungal |
| Chocolate and cocoa | Manufacture of syrups | Amylase | Fungal/bacterial |
| Coffee | Coffee bean fermentation | Pectinase | Fungal |
| | Preparation of coffee concentrates | Pectinase, hemicellulase | Fungal |
| Confectionery | Manufacture of soft center candies | Invertase, pectinase | Fungal/bacterial |

| Industry | Application | Enzyme | Source |
|---|---|---|---|
| Cotton | Low temperature processing | Pectate lyase | Fungal |
| Corn syrup | Manufacture of high-maltose syrups | Amylase | Fungal |
| | Production of low D.E. syrups | Amylase | Bacterial |
| | Production of glucose from corn syrup | Amyloglycosidase | Fungal |
| | Manufacture of fructose syrups | Glucose isomerase | Bacterial |
| Dairy | Manufacture of protein hydrolysates | Protease | Fungal/bacterial |
| | Stabilization of evaporated milk | Protease | Fungal |
| | Production of whole milk concentrates, ice cream, and frozen desserts | Lactase | Yeast |
| | Curdling milk | Protease | Fungal/bacterial |
| Eggs, dried | Glucose removal | Glucose oxidase | Fungal |
| Fruit juices | Clarification | Pectinases | Fungal |
| | Oxygen removal | Glucose oxidase | Fungal |
| Laundry | Detergents | Protease, lipase | Bacterial |
| Leather | Dehairing, baiting | Protease | Fungal/bacterial |
| Meat | Tenderization | Protease | Fungal |
| Paper | Removal of wood waxes | Lipase | Fungal |
| Pharmaceutical | Digestive aids | Amylase, protease | Fungal |

*Cont…*

| Industry | Application | Enzyme | Source |
|---|---|---|---|
| | Antiblood clotting | Streptokinase | Bacterial |
| | Various clinical tests | Numerous | Fungal/bacterial |
| | Biotransformations | Numerous | Fungal/bacterial |
| Photography | Recovery of silver from spent film | Protease | Bacterial |
| Protein hydrolysates | Manufacture | Proteases | Fungal/bacterial |
| Soft drinks | Stabilization | Glucose oxidase, catalase | Fungal |
| Textiles | Desizing of fabrics | Amylase | Bacterial |
| Vegetables | Preparation of purees and soups | Pectinase, amylase, cellulase | Fungal |

# MICROBIAL METABOLITES

Many products of primary metabolism are of considerable economic importance and are being produced by fermentation.

The synthesis of anabolic primary metabolites by wild-type microorganisms is such that their production is sufficient to meet the requirements of the organism.

The industrial microbiologist to modify the wild-type organism and to provide cultural conditions to improve the productivity of these compounds.

**Table 1.2** Some Primary Products of Microbial Metabolism and Their Commercial Significance

| Primary Metabolite | Commercial Significance |
|---|---|
| Ethanol | "Active ingredient" in alcoholic beverages |
| | Used as a motor-car fuel when blended with petroleum |
| Organic acids | Various uses in the food industry |
| Glutamic acid | Flavor enhancer |
| Lysine | Feed supplement |
| Nucleotides | Flavor enhancers |
| Phenylalanine | Precursor of aspartame, sweetener |
| Polysaccharides | Applications in the food industry |
| | Enhanced oil recovery |
| Vitamins | Feed supplements |

# The Interrelationships Between Primary and Secondary Metabolism