AN INTRODUCTION TO FERMENTATION PROCESS
WHAT IS FERMENTATION

- Conversion of sugar to alcohol using yeast.
- Chemical conversion of carbohydrates into alcohols or acids.
- The process is often used to produce wine and beer.
- Also employed in preservation to create lactic acid in sour foods such as pickled cucumbers, kimchi and yogurt.
- The science of fermentation is known as zymology.
Biochemistry perspective

- Process that is important in anaerobic conditions when there is no oxidative phosphorylation to maintain the production of ATP (Adenosine triphosphate) by glycolysis.
- During fermentation pyruvate is metabolised to various different compounds.
- Homolactic fermentation is the production of lactic acid from pyruvate; alcoholic fermentation is the conversion of pyruvate into ethanol and carbon dioxide.
- Heterolactic fermentation is the production of lactic acid as well as other acids and alcohols.
• Typical examples of fermentation products are **ethanol**, **lactic acid**, and **hydrogen**.

• However, more exotic compounds can be produced by fermentation, such as **butyric acid** and **acetone**.
Fermentation is derived from the Latin word *fermentare* - to leaven to rise

Verb - *Fevere* - to boil

Describing the appearance of the action of yeast on 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 sugars present in the extracts.

Fermentation have different meaning to biochemistry and industrial microbiologists.

Biochemical meaning relates to the generation of energy by the catabolism of organic compounds.

Whereas meaning in industrial microbiology tends to be much broader.
The catabolism of sugars is an oxidative process which results in the production of reduced pyridine nucleotides which must be reoxidized for the process to continue.

Under-aerobic conditions, reoxidation of reduced pyridine nucleotide occurs by electron transfer, via the cytochrome system, with oxygen acting as the terminal electron acceptor.

Under anaerobic conditions, reduced pyridine nucleotide oxidation is coupled with the reduction of an organic compound, which is often a subsequent product of the catabolic pathway.
In the case of the action of yeast on fruit or grain extracts, NADH is regenerated by the reduction of pyruvic acid to ethanol.

Different microbial taxa are capable of reducing pyruvate to a wide range of end products.

Thus, the term fermentation has been used in a strict biochemical sense to mean an energy generation process in which organic compounds act as both electron donors and terminal electron acceptors.
Industrial microbiologists have extended the term - fermentation - to describe:

- Any process for the production of product by the mass culture of microorganism.
- Brewing and the production of organic solvents may be described as fermentation in both senses of the word.
Respiration and Fermentation

Pyruvic acid

CH₂-C-C-OH

NADH

NAD⁺

CO₂

Lactic acid

CH₂-CH-C-OH

Acetaldehyde

CH₃-C-H

Ethanol

CH₃-CH₂-OH
Glucose → Pyruvic acid

**Organisms**
- Propionibacterium: CO₂, propionic acid
- Aspergillus Lactobacillus Streptococcus: lactic acid
- Saccharomyces: CO₂, ethanol
- Clostridium: acetone, isopropanol
- Escherichia Acetobacter: acetic acid

**Fermentation products**
- Swiss cheese
- Cheddar cheese, yogurt, soy sauce
- Wine, beer
- Nail polish remover, rubbing alcohol
- Vinegar
• NADH reduces pyruvic acid to form lactic acid.

• Another simple fermentation pathway involved a decarboxylation reaction to form ethanol.

• This is representative fermentation products and the organism that produce them.

• All of the organisms are bacteria except Saccharomyces, which is yeast.

• Different organism will produced different end products.
The range of fermentation process.

There are five major groups of commercially important fermentations:

- Those that produce microbial cells (or biomass) as the product.
- Those that produce microbial enzymes
- Those that produce microbial metabolites.
- Those that produce recombinant products.
- Those that modify a compound which is added to the fermentation - the transformation
THE COMPONENT PARTS OF A FERMENTATION PROCESS

(1) The formulation of media to be used in culturing the process organism during the development of the inoculums and in the production fermenter.

(2) The sterilization of the medium, fermenters and ancillary equipment.

(3) The production of an active, pure culture in sufficient quantity to inoculate the production vessel.
(4) The **growth** of the organism in the production fermenter under optimum conditions for product formation.

(5) The **extraction** of the product and its **purification**.

(6) The **disposal of effluents** produced by the process.
Interrelationships between the six component parts