FERMENTATION

AND ITS TYPES

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INTRODUTION TO FERMENTATION

Fermentation is a metabolic process that converts sugar to acids, gases or alcohol. It occurs in yeast and bacteria, and also in oxygen-starved (Deficient) muscle cells, as in the case of lactic acid **fermentation**.

Fermentation, chemical process by which molecules such as glucose are broken down anaerobically. More

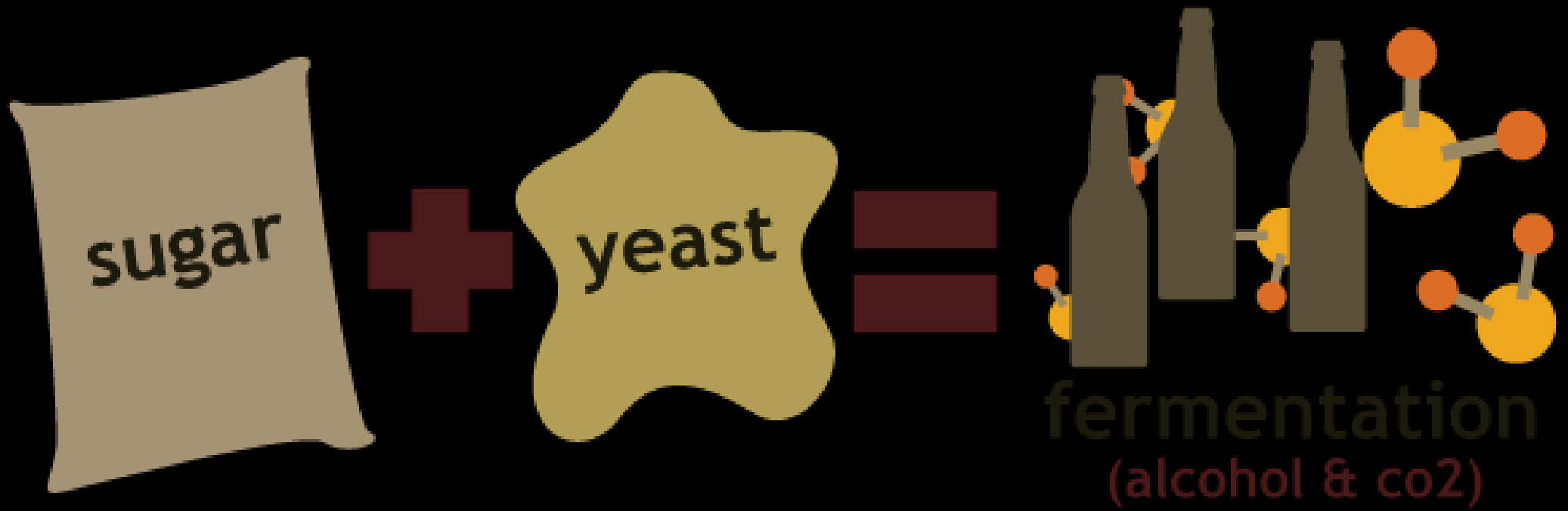
broadly, fermentation is the foaming (Un-healthy) that occurs during the manufacture of wine and beer, a process at least 10,000 years old. The frothing results from the evolution of carbon dioxide gas, though this was not recognized until the 17th century. French chemist and microbiologist Louis Pasteur in the 19th century used the term fermentation in a narrow sense to describe the

changes brought about by yeasts and other microorganisms growing in the absence of air (anaerobically); he also recognized that ethyl alcohol and carbon dioxide are not the only products of fermentation.

Definition:

Fermentation is the chemical transformation of organic substances into simpler compounds by the action of enzymes, complex organic catalysts, which are produced by microorganisms such as molds, yeasts, or bacteria.

Enzymes act by hydrolysis, a process of breaking down or predigesting complex organic molecules to form smaller (and in the case of foods, more easily digestible) compounds and nutrients.


sugar
yeast
fermentation
(alcohol & co2)

HISTORY OF FERMENTATION

Fermentation is a natural process. People applied fermentation to make products such as wine, mead (Made of Fermented honey and water), cheese and beer long before the biochemical process was understood. In the 1850s and 1860s Louis Pasteur became the first zymurgist (One who

expert in the field of fermentation) or scientist to study fermentation when he demonstrated fermentation was caused by living cells.

The first solid evidence of the living nature of yeast appeared between 1837 and 1838 when three publications appeared by C. Cagniard de la Tour, T. Swann, and F. Kuetzing, each of whom independently concluded as a result of microscopic investigations that yeast was a living organism that reproduced by budding. The word "yeast," it

should be noted, traces its origins back to the Sanskrit word meaning "boiling." It was perhaps because wine, beer, and bread were each basic foods in Europe, that most of the early studies on fermentation were done on yeasts, with which they were made. Soon bacteria were also discovered; the term was first used in English in the late 1840s, but it did not come into general use until the 1870s, and then largely in connection with the new germ theory of disease.

The view that fermentation was a process initiated by living organisms soon aroused fierce criticism from the finest

chemists of the day, especially Justus von Liebig, J.J. Berzelius, and Friedrich Woehler. This view seemed to give new life to the waning mystical philosophy of vitalism, which they had worked so hard to defeat. Proponents of vitalism held that the functions of living organisms were due to a vital principal (life force, *chi*, *ki*, *prana* , etc.) distinct from physico-chemical forces, that the processes of life were not explicable by the laws of physics and chemistry alone, and that life was in some part self determining. As we shall soon see, the vitalists played a key role in debate on the nature of

fermentation. A long battle ensued, and while it was gradually recognized that yeast was a living organism, its exact function in fermentations remained a matter of controversy. The chemists still maintained that fermentation was due to catalytic action or molecular vibrations.

The debate was finally brought to an end by the great French chemist Louis Pasteur (1822-1895) who, during the 1850s and 1860s, in a series of classic investigations, proved conclusively that fermentation was initiated by living organisms. In 1857 Pasteur showed that lactic acid

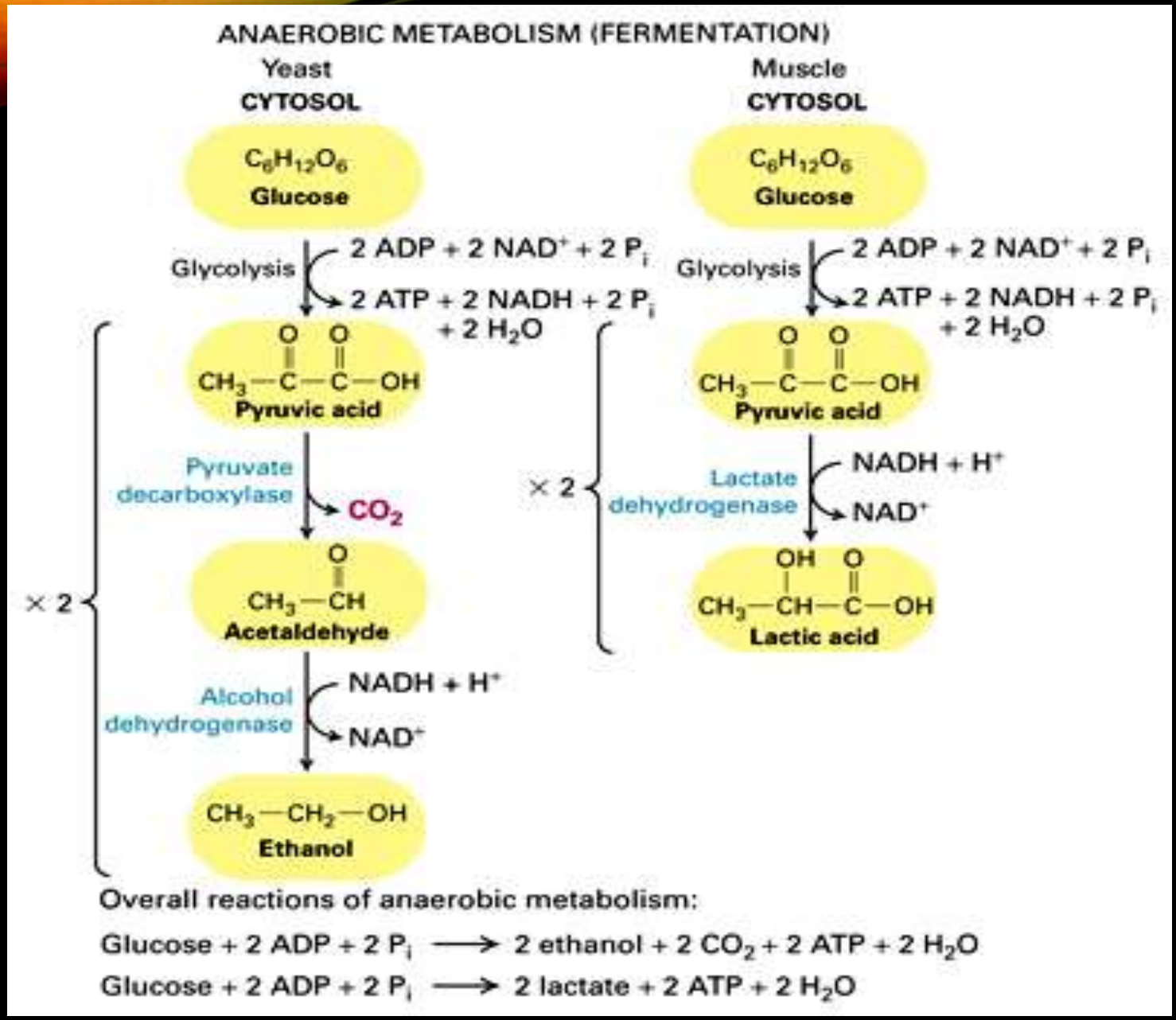
fermentation is caused by living organisms. In 1860 he demonstrated that bacteria cause souring in milk, a process formerly thought to be merely a chemical change, and his work in identifying the role of microorganisms in food spoilage led to the process of pasteurization. In 1877, working to improve the French brewing industry, Pasteur published his famous paper on fermentation, *Etudes sur la Biere* , which was translated into English in 1879 as *Studies on Fermentation* . He defined fermentation (incorrectly) as "Life without air," but correctly showed specific types of

microorganisms cause specific types of fermentations and specific end products. In 1877 the era of modern medical bacteriology began when Koch (a German physician; 1843-1910) and Pasteur showed that the anthrax bacillus caused the infectious disease anthrax. This epic discovery led in 1880 to Pasteur's general germ theory of infectious disease, which postulated for the first time that each such disease was caused by a specific microorganism. Koch also made the very significant discovery of a method for isolating microorganisms in pure culture.

TYPES BASED ON RESPIRATION (AEROBIC AND AN-AEROBIC)

Aerobic Fermentation: Aerobic fermentation means that oxygen is present. Wine, beer and acetic acid vinegar (such as apple cider vinegar), need oxygen in the “primary” or first stage of fermentation.

When creating acetic vinegar, for example, exposing the surface of the vinegar to as much oxygen as possible, creates a healthy, flavorful vinegar with the correct pH.



Aerobic Fermentation

Anaerobic Fermentation: Anaerobic fermentation is a method cells use to extract energy from carbohydrates when oxygen or other electron acceptors are not available in the surrounding environment. This differentiates it from anaerobic respiration, which doesn't use oxygen but does use electron-accepting molecules that come from outside of the cell. The process can follow glycolysis as the next step in the breakdown of glucose and other sugars to produce molecules of adenosine triphosphate (ATP) that create an energy source for the cell.

Through this method, a cell is able to regenerate nicotinamide adenine dinucleotide (NAD+) from the reduced form of nicotinamide adenine dinucleotide (NADH), a molecule necessary to continue glycolysis. Anaerobic fermentation relies on enzymes to add a phosphate group to an individual adenosine diphosphate (ADP) molecule to produce ATP, which means it is a form of substrate-level phosphorylation. This contrasts with oxidative phosphorylation, which uses energy from an established proton gradient to produce ATP.

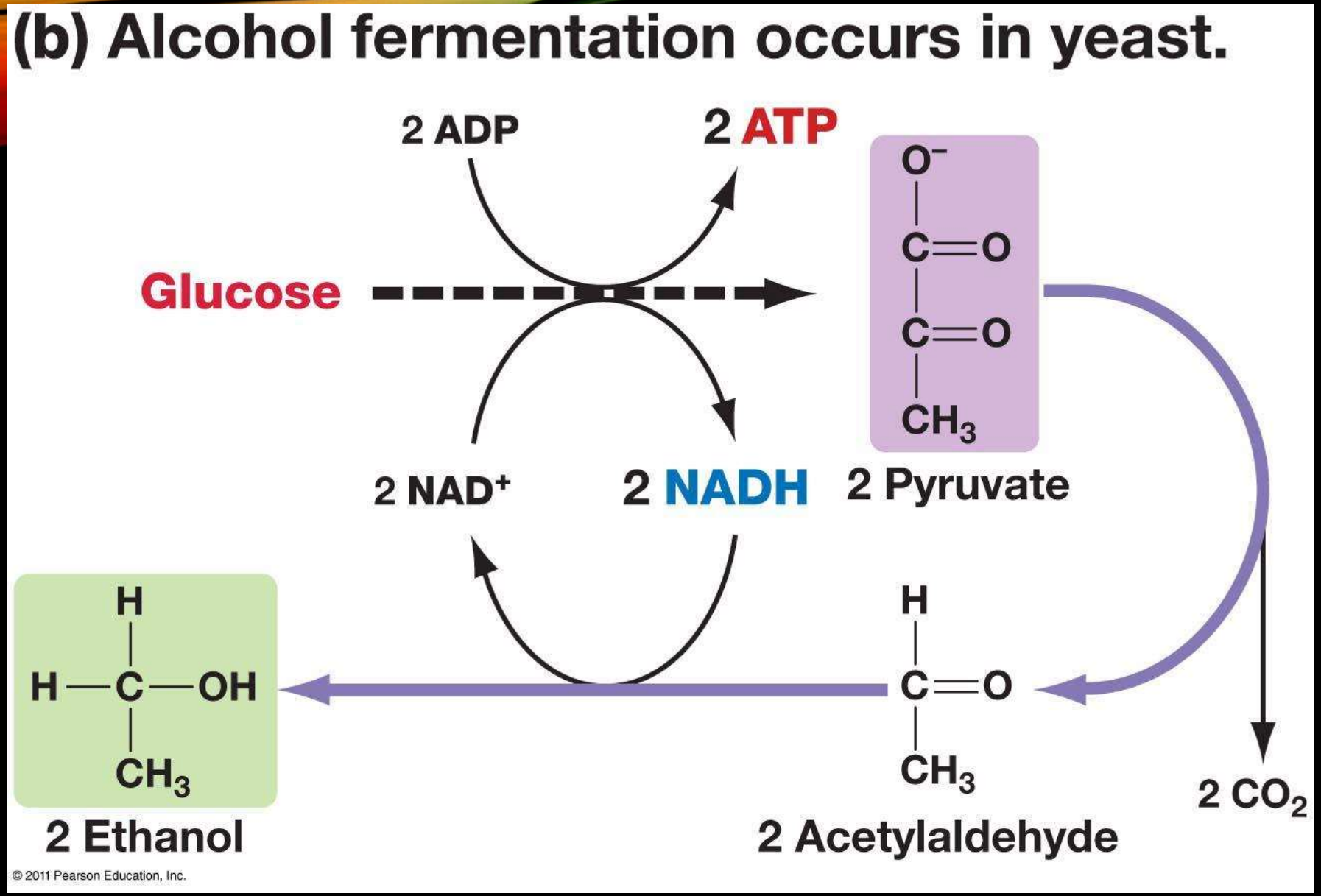
There are two major types of anaerobic fermentation: ethanol fermentation and lactic acid fermentation. Both restore NAD+ to allow a cell to continue generating ATP through glycolysis.

Ethanol fermentation: Ethanol fermentation converts two pyruvate molecules, the products of glycolysis, to two molecules of ethanol and two molecules of carbon dioxide. The reaction is a two-step process in which pyruvate is converted to acetaldehyde and carbon dioxide first, by the enzyme pyruvate decarboxylase.

Yeast and certain bacteria perform ethanol fermentation where pyruvate (from glucose metabolism) is broken into ethanol and carbon dioxide. The net chemical equation for the production of ethanol from glucose is:

$C_6H_{12}O_6$ (glucose) → 2 C_2H_5OH (ethanol) + 2 CO_2 (carbon dioxide)

Ethanol fermentation is used the production of beer, wine and bread. It's worth noting that fermentation in the presence of high levels of pectin result in the production of small amounts of methanol, which is toxic when consumed.



Anaerobic fermentation -1

Lactic acid fermentation: Lactic acid fermentation is a biological process by which glucose and other six-carbon sugars (also, disaccharides of six-carbon sugars, e.g. sucrose or lactose) are converted into cellular energy and the metabolite lactate.

The pyruvate molecules from glucose metabolism (glycolysis) may be fermented into lactic acid. Lactic acid fermentation is used to convert lactose into lactic acid in yogurt production. It also occurs in animal muscles when

the tissue requires energy at a faster rate than oxygen can be supplied. The next equation for lactic acid production from glucose is:

$C_6H_{12}O_6$ (glucose) $\rightarrow$ 2 $CH_3CHOHCOOH$ (lactic acid)

The production of lactic acid from lactose and water may be summarized as:

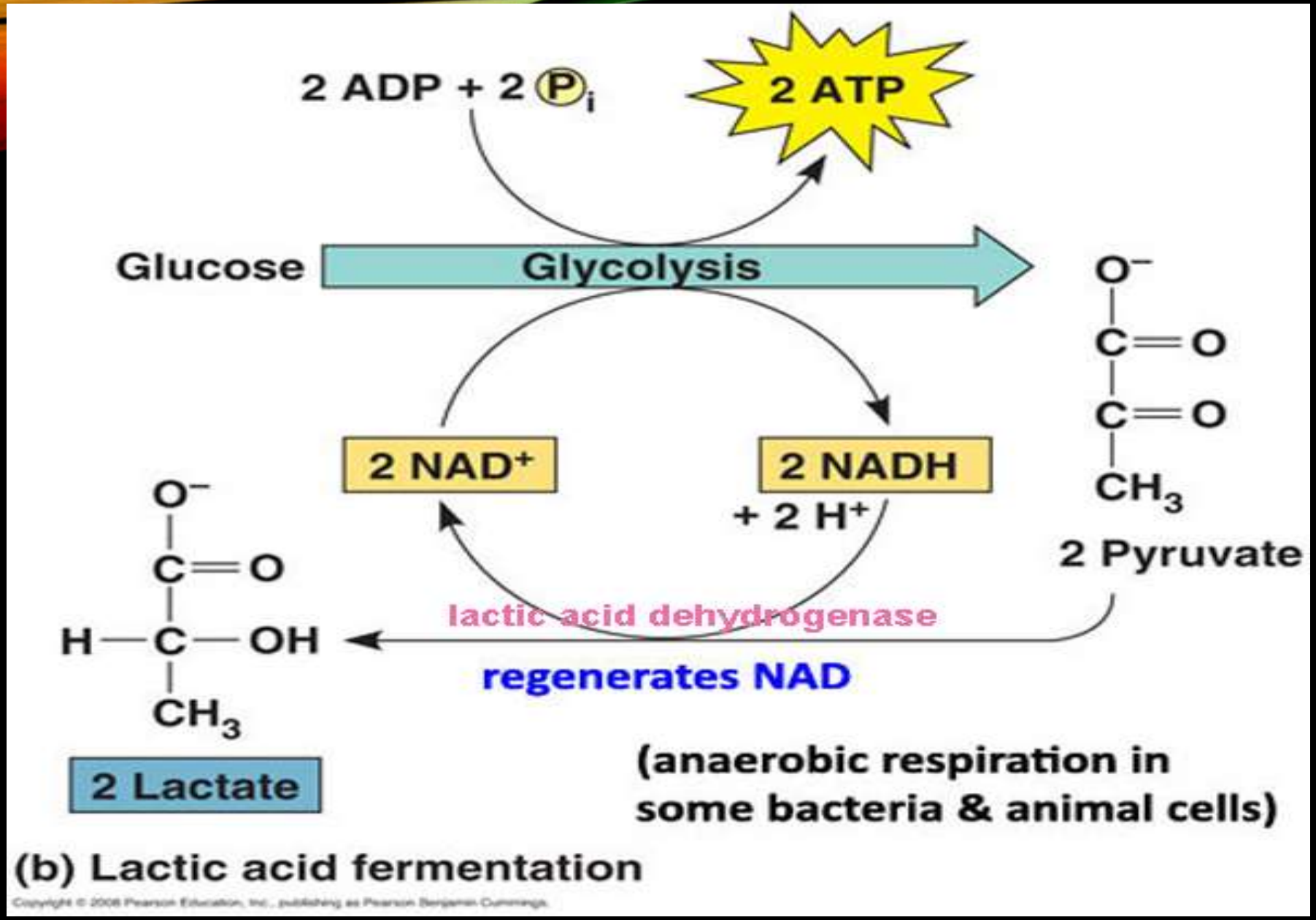
$C_{12}H_{22}O_{11}$ (lactose) + H_2O (water) $\rightarrow$ 4 $CH_3CHOHCOOH$ (lactic acid)

Yogurt is made by fermenting milk. It's high in protein, calcium, and probiotics ("good" bacteria). Here's how to make yogurt and a look at the chemistry of yogurt.

TYPES OF FERMENTATION

Homo Lactic fermentation: The fermentation in which only the lactic acid is produced. There is no any side product formed after the reaction.

Hetero-Lactic Fermentation: The Fermentation in which the lactic acid is produced along with some by products like gases.



Anaerobic fermentation -2

MECHANISM OF FERMENTATION

Fermentation takes place when the electron transport chain is unusable (often due to lack of a final electron receptor, such as oxygen), and becomes the cell's primary means of ATP (energy) production.[1] It turns NADH and pyruvate produced in glycolysis into NAD+ and an organic molecule (which varies depending on the type of fermentation; see examples below). In the presence of O2, NADH and pyruvate are used to generate ATP in respiration. This is called

oxidative phosphorylation, and it generates much more ATP than glycolysis alone. For that reason, cells generally benefit from avoiding fermentation when oxygen is available, the exception being obligate anaerobes which cannot tolerate oxygen.

The first step, glycolysis, is common to all fermentation pathways this is the cause of fermentation:

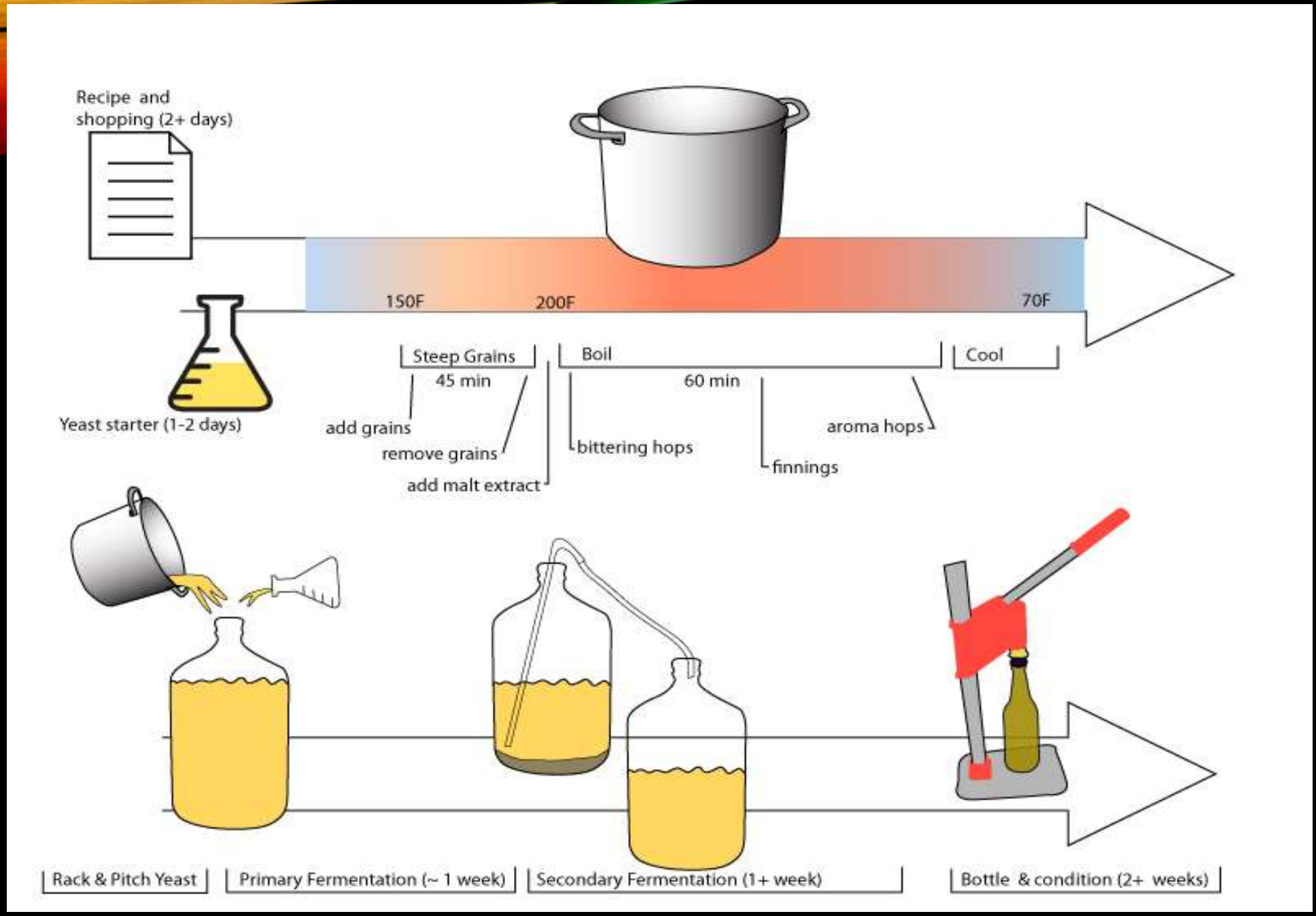
$C_6H_{12}O_6 + 2\ NAD^+ + 2\ ADP + 2\ Pi \rightarrow 2\ CH_3COCOO^- + 2\ NADH + 2\ ATP + 2\ H_2O + 2H^+$

Pyruvate is CH_3COCOO^-. Pi is inorganic phosphate. Two ADP molecules and two Pi are converted to two ATP and two water molecules via substrate-level phosphorylation. Two molecules of NAD^+ are also reduced to NADH.

In oxidative phosphorylation the energy for ATP formation is derived from an electrochemical proton gradient generated across the inner mitochondrial membrane (or, in the case of bacteria, the plasma membrane) via the electron transport chain. Glycolysis has substrate-level phosphorylation (ATP generated directly at the point of reaction).

Humans have used fermentation to produce food and beverages since the Neolithic age. For example,

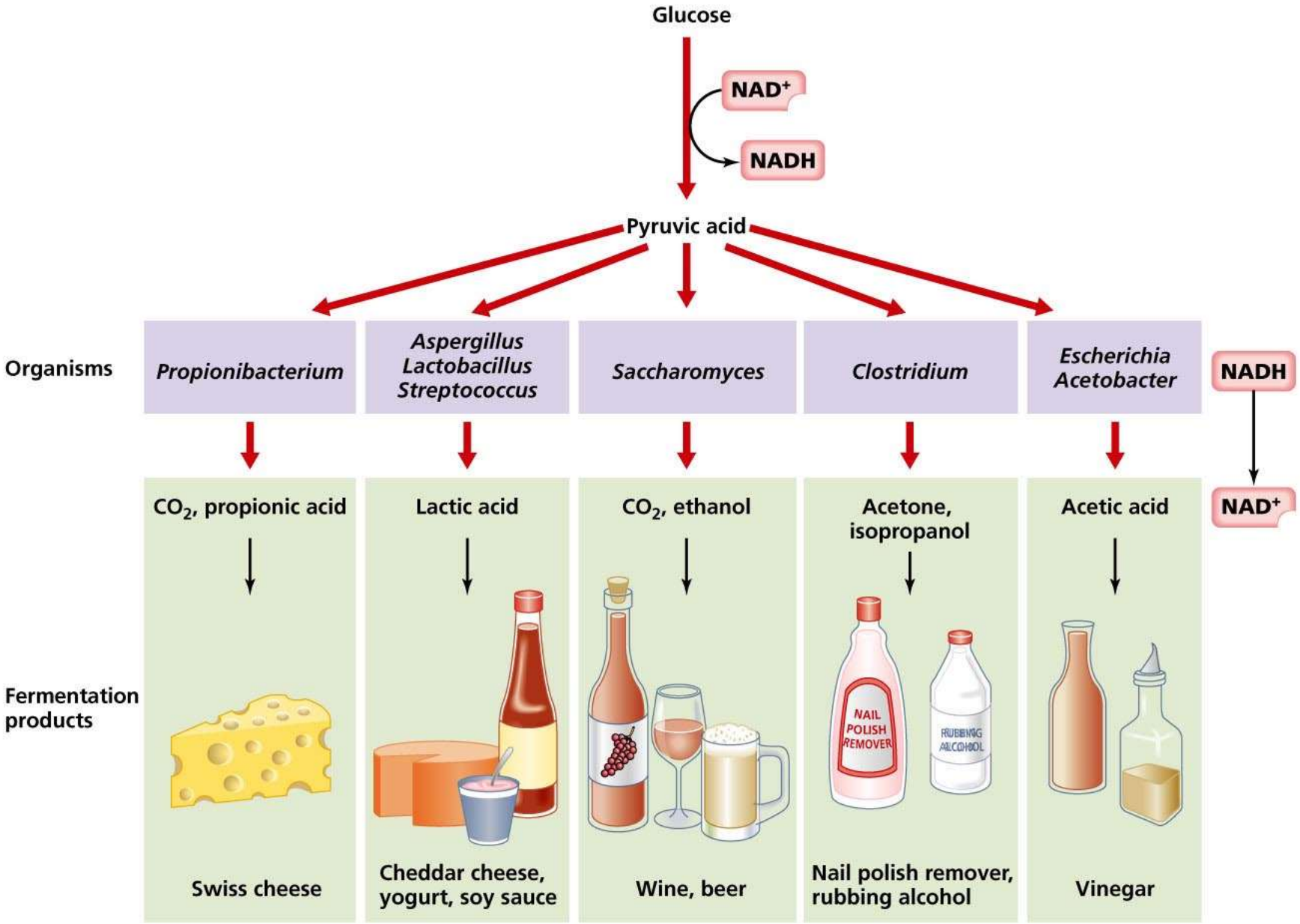
fermentation is used for preservation in a process that produces lactic acid as found in such sour foods as pickled cucumbers, kimchi and yogurt (see fermentation in food processing), as well as for producing alcoholic beverages such as wine (see fermentation in winemaking) and beer. Fermentation can even occur within the stomachs of animals, such as humans.


Recipe and
shopping (2+ days)
150F
200F
70F
Steep Grains
45 min
Boil
60 min
Cool
Yeast starter (1-2 days)
add grains
remove grains
add malt extract
bittering hops
finnings
aroma hops
Rack & Pitch Yeast
Primary Fermentation (~ 1 week)
Secondary Fermentation (1+ week)
Bottle & condition (2+ weeks)

PRODUCTS OF FERMENTATION

- ➔ Wine
- ➔ Beer
- ➔ Lactic acid
- ➔ Vinegar
- ➔ Yogurts
- ➔ cheese
- ➔ Sauerkraut
- ➔ Kimchi
- ➔ Pepperoni

ETC……..



FERMENTATION AS A FOOD PRESERVATION TECHNIQUE

Fermented foods are foods that have been prepared in a way so that the bacteria naturally found within them starts to ferment. Fermentation, also known as lacto-fermentation, is a chemical process in which bacteria and other micro-organisms break down starches and sugars within the foods, possibly making them easier to digest, and resulting in a product that is filled with helpful organisms and enzymes.

This process of fermentation is a natural preservative, which means that fermented foods can last a long time.

ADVANTAGES AND DIS ADVANTAGES OF FERMENTATION

Advantages of fermentation are that lactic acid can be produced and it can produce energy for ATPs.

Disadvantages of fermentation are that production can be slow, the product is impure and needs to have further treatment and the production carries a high cost and more energy.

Advantages and Disadvantages of Fermentation

- Fermentation can provide a rapid burst of ATP in muscle cells, even when oxygen is in limited supply.
- Lactate, however, is toxic to cells.
- Initially, blood carries away lactate as it forms; eventually lactate builds up, lowering cell pH, and causing muscles to fatigue.
- *Oxygen debt* occurs, and the liver must reconvert lactate to pyruvate.

IMPORTANCE OF FERMENTATION

Fermentation is important to cells that don't have oxygen or cells that don't use oxygen because:

1. It allows the cells to get 2 ATP gain from one molecule of glucose, even without oxygen.
2. Fermentation takes away the end products of glycolysis so glycolysis can continue ... freeing up the electron carriers, and so on.

3. Fermentation is important to the baking industry because it is the process that yeast uses to produce the bubbles of carbon dioxide that make the dough rise.
4. Fermentation is important in wineries and breweries because yeast uses fermentation to produce alcohol.
5. Fermentation is important in muscles because it allows the muscles to keep getting a little energy from glucose even when the oxygen supply can't keep up with the demand.

THANK YOU