

## Aerobic and Anaerobic Respiration

**Aerobic** denotes the term 'in the presence of oxygen' while the word **anaerobic** denotes the 'absence of oxygen'. So the respiration which occurs in the **presence of oxygen** is called as aerobic respiration, on the other hand, respiration occurring in the **absence of oxygen** is known as anaerobic respiration.

So accordingly the chemical reaction involving the breakdown of the nutrient molecule with the aim of producing energy is called **respiration**. Thus the energy required by the body to perform well which is produced by the chemical reaction. This process takes place in the mitochondria or in the cytoplasm of the cell either aerobically or anaerobically.

Below we will consider the important points which distinguish the aerobic respiration to that of anaerobic respiration.

<b>BASIS FOR COMPARISON</b>	<b>AEROBIC RESPIRATION</b>	<b>ANAEROBIC RESPIRATION</b>
<b>Definition</b>	The breakdown of glucose in the presence of oxygen to produce more amount of energy is called as aerobic respiration.	The breakdown of glucose in the absence of oxygen to produce energy is called as anaerobic respiration.
<b>Chemical Equation</b>	Glucose + Oxygen gives Carbon dioxide + water + energy	Glucose gives Lactic acid + energy
<b>It occurs in</b>	The cytoplasm to mitochondria.	Takes place in cytoplasm only.
<b>Energy produced</b>	The high amount of energy is produced.	Less amount of energy produced.
<b>Number of ATP released</b>	38 ATP.	2 ATP.
<b>Final product is</b>	Carbon dioxide and water.	Lactic acid (animal cells), carbon dioxide and ethanol (plant cell).
<b>It requires</b>	Oxygen and glucose to produce energy.	It does not require oxygen but uses glucose to produce energy.
<b>It involves</b>	<ol style="list-style-type: none"><li>1. Glycolysis - also called Embden-Meyerhof-Parnas(EMP) pathway.</li><li>2. The respiratory chain (electron transport and oxidative phosphorylation).</li><li>3. The tricarboxylic acid cycle (TCA),</li></ol>	<ol style="list-style-type: none"><li>1. Glycolysis.</li><li>2. Fermentation</li></ol>

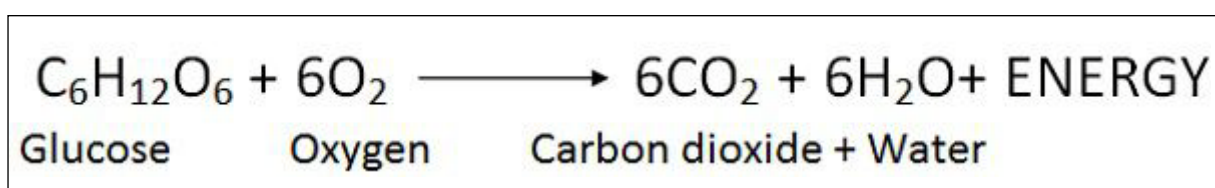
BASIS FOR COMPARISON	AEROBIC RESPIRATION	ANAEROBIC RESPIRATION
	also known as the citric acid cycle or Krebs cycle.	
<b>Process of combustion</b>	Complete	Incomplete.
<b>Type of process</b>	It is a long process for the production of energy.	It is a fast process in comparison to aerobic respiration.
<b>Examples</b>	Aerobic respiration occurs in many plants and animals (eukaryotes).	Anaerobic respiration occurs in human muscle cells (eukaryotes), bacteria, yeast (prokaryotes), etc.

### Definition of Aerobic Respiration

Aerobic respiration can be described as the chain of reactions **catalyzed by enzymes**. The mechanism involves the transfer of electrons from the molecules acting as the source of fuel like **glucose** to the oxygen which works as the final electron acceptor.

This is the principal pathway for yielding the **energy** in aerobic respiration. This scheme at the end provides ATP and metabolic intermediates, working as the precursor for many other pathways in the cell, like carbohydrates, lipid and protein synthesis.

Thus the equation can be summarized as:



So the **total yield of ATP** is 40: Two from glycolysis, two from the TCA, and 34 from electron transport gives **38 ATP at a time**.

While the amount of total energy released is **2900 kJ/mol** of glucose. There is no production of lactic acid. The aerobic respiration process goes on continuously in the body of plants and animals.

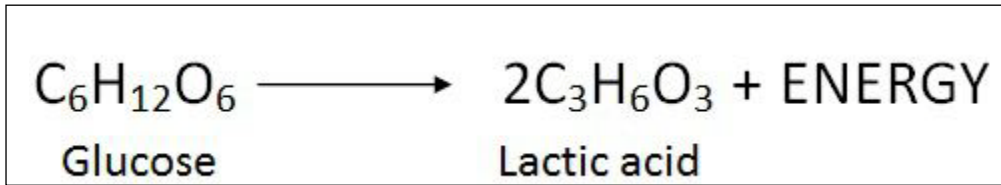
### Definition of Anaerobic Respiration

Anaerobic respiration can be distinguished from that of aerobic respiration regarding the **involvement of oxygen** while converting the given resources such as glucose into energy.

Some bacteria, have evolved this kind of system where it utilizes oxygen-containing salts, rather using free oxygen as the electron acceptor. The energy produced by the anaerobic respiration is

useful at the time of high energy demand in tissues when the oxygen produced by aerobic respiration is not able to fulfill the required demand. Though it is produced in very less amount as compared to aerobic respiration.

Thus the equation can be summarized as



As in the above reaction, glucose does not completely break down, and hence it produces very less energy. So the total amount of the energy released regarding kilo per joules is **120 kJ/mol** of glucose. It produces lactic acid.

### Key Differences Between the Aerobic Respiration and Anaerobic Respiration

Following are the substantial differences between both kind of respiration:

1. The breakdown of glucose in the presence of oxygen to produce more amount of energy is called as **aerobic respiration**; Whereas the breakdown of glucose in the absence of oxygen to produce energy is called as **anaerobic respiration**.
2. **Chemical Equation** of aerobic respiration is Glucose + Oxygen gives Carbon dioxide + water + energy whereas the equation of anaerobic respiration is Glucose gives Lactic acid + energy
3. Aerobic respiration **occurs in** the cytoplasm to mitochondria, while anaerobic respiration occurs in the cytoplasm only.
4. **The high amount** of energy is produced and **38 ATP** released at a time in aerobic respiration; **Less amount** of energy is produced and **2 ATP** are released at a time in anaerobic respiration.
5. **Final product** in aerobic respiration are carbon dioxide and water, whereas Lactic acid (animal cells), carbon dioxide and ethanol (plant cell) is the final product in anaerobic respiration.
6. Aerobic respiration **requires** oxygen and glucose to produce energy whereas in anaerobic respiration does not require oxygen but uses glucose to produce energy.
7. The **stages involved** in aerobic respiration are – 1. Glycolysis – also called Embden-Meyerhof-Parnas(EMP) pathway; 2.The respiratory chain (electron transport and oxidative phosphorylation); 3. The tricarboxylic acid cycle (TCA), also known as citric acid cycle or Krebs cycle whereas the anaerobic respiration involves the two stages only which is 1. Glycolysis and 2.Fermentation
8. Aerobic respiration shows complete process of **combustion**, while it is incomplete in the anaerobic respiration.
9. Aerobic respiration is a **long process** for the production of energy whereas anaerobic respiration is a **fast process** in comparatively.

10. **Examples** of aerobic respiration occurs in many plants and animals (eukaryotes) whereas anaerobic respiration occurs in human muscle cells (eukaryotes), bacteria, yeast (prokaryotes), etc.

### **Fermentation Definition**

Fermentation is a metabolic process in which an organism converts a carbohydrate, such as starch or a sugar, into an alcohol or an acid. For example, yeast performs fermentation to obtain energy by converting sugar into alcohol. Bacteria perform fermentation, converting carbohydrates into lactic acid. The study of fermentation is called **zymology**.

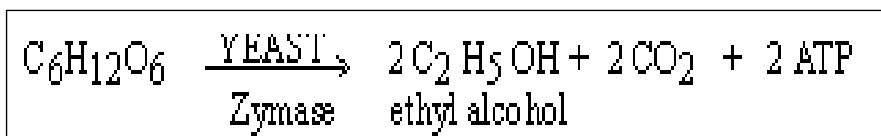
Any form of fermentation that produces a single acid, but especially the anaerobic conversion of pyruvic acid into lactic acid with concomitant oxidation of NADH to NAD.

### **Fermentation**

Fermentation is of different types and takes place under anaerobic conditions mostly in saprophytic microorganisms like certain bacteria and fungi. However, it may also take place in higher organisms under certain conditions.

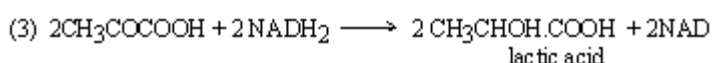
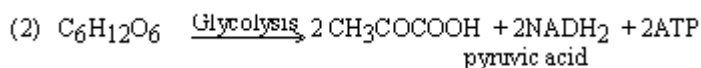
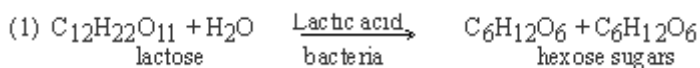
The two most common types of fermentation are (1) **alcoholic** fermentation and (2) **lactic acid** fermentation.

(1) **Alcoholic fermentation** : the type of fermentation in which ethyl alcohol is the main end product .This is very common in yeast (unicellular fungus) and also seen in some bacteria. Yeast cells release enzymes called **zymase** complex which bring about the fermentation. The reactions are similar to anaerobic respiration.



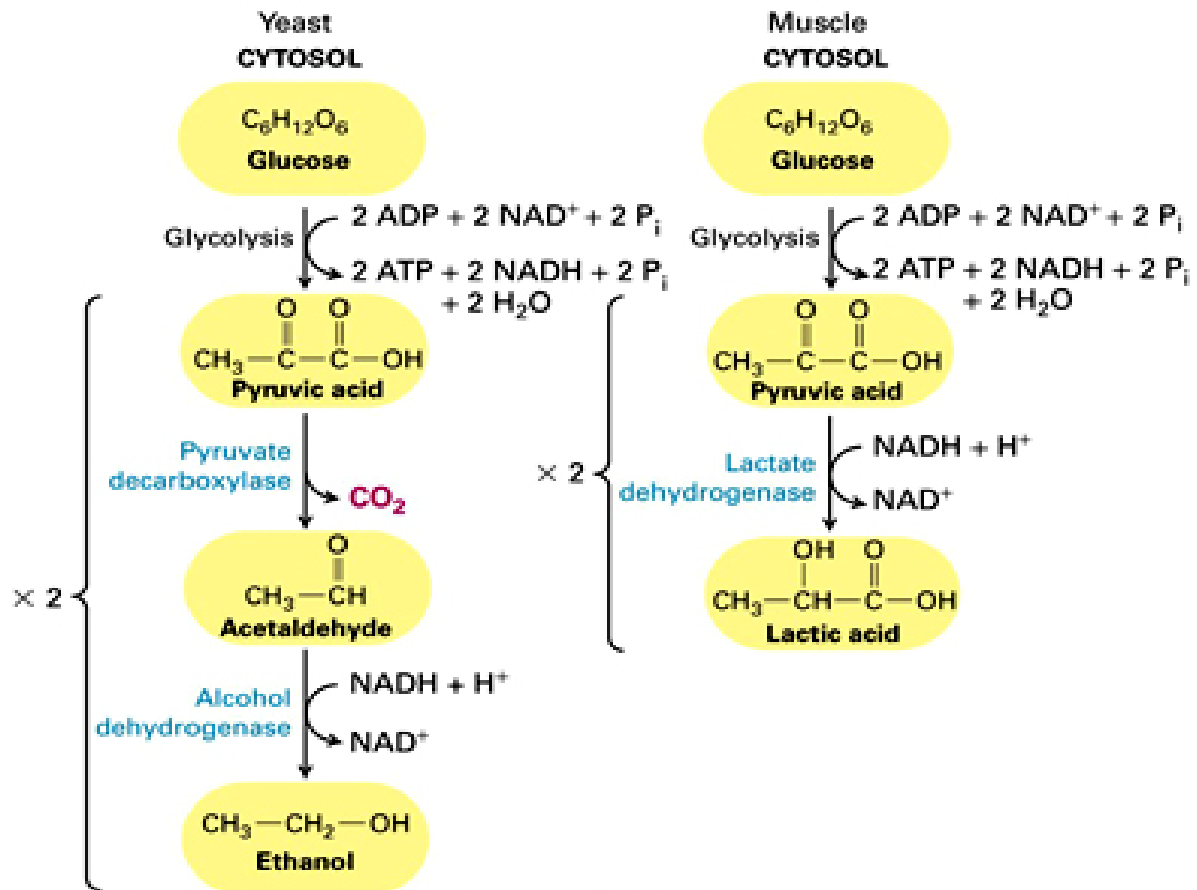
(2) **Lactic acid fermentation**: The type of fermentation in which lactic acid is the end product. It is carried out by some bacteria (e.g. lactic acid bacteria), and also by animals (muscle glycolysis in animals, under oxygen deficiency, results in the formation of lactic acid this is why we experience in muscle cramps.

Lactic acid bacteria can ferment milk sugar lactose ( $C_{12}H_{22}O_{11}$ ) to lactic acid. The process is extracellular.



This brings about curdling of milk.

**ANAEROBIC METABOLISM (FERMENTATION)**



Overall reactions of anaerobic metabolism:

