All organisms breathe- a process in which they take in oxygen and give off carbon dioxide. Internal respiration or cellular respiration takes place inside every living cell. In this process, carbohydrates and other organic molecules are broken down in successive steps to produce energy, which is used to make a compound called Adenosine Triphosphate(ATP). Cellular processes get energy from ATP. It is commonly called 'energy currency' of the cell.

Oxidation: It means breakdown of food to provide energy with the help of oxygen.

Respiration

- It is defined as the process of biochemical oxidation of nutrients in the presence of specific enzymes at optimum temperature in the cells to release energy for metabolic activities.
- During photosynthesis, carbon dioxide and water combine with the help of the energy from the sun to form carbohydrates. Energy gets stored in the bonds of the carbohydrates. In respiration, these bonds are broken to release energy and give back carbon dioxide and water. This energy then gets stored in the bonds of ATP. This molecule is oxidized and broken down gradually in two different stages.
- The first stage is called 'glycolysis', which involves anaerobic respiration. The second stage involves aerobic respiration.

$$\text{Glucose} + O_2 \dashrightarrow \text{Energy (ATP)} + CO_2 + H_2O$$

Respiratory substrate : The organic substances undergoing oxidative breakdown during respiration are called 'respiratory substrates', e.g. glucose, which is obtained from digestion of carbohydrate.

Starch, Glycogen (polysaccharide) $\xrightarrow{\text{Digestion}}$ **Glucose** $\xrightarrow{\text{Oxidation}}$ **Energy (ATP) + CO_2 + HO**

Breathing: It is a physical process that sends fresh air/water (rich in O_2) to respiratory organs and removes foul air/water (rich in carbon dioxide) from them

Gaseous Exchange in Unicellular Organism

In unicellular organisms, simple diffusion through body surface is sufficient for exchange of gases necessary for respiration because the cell is in continuous contact with the external environment.

Gaseous Exchange in Multicellular Organism: In simple multicellular organisms like poriferans and coelenterates, respiration occurs by simple diffusion because most of their cells are in contact with external environment. But in complex multicellular organisms a respiratory system is needed for effective gas exchange because all cells are not in direct contact with external environment

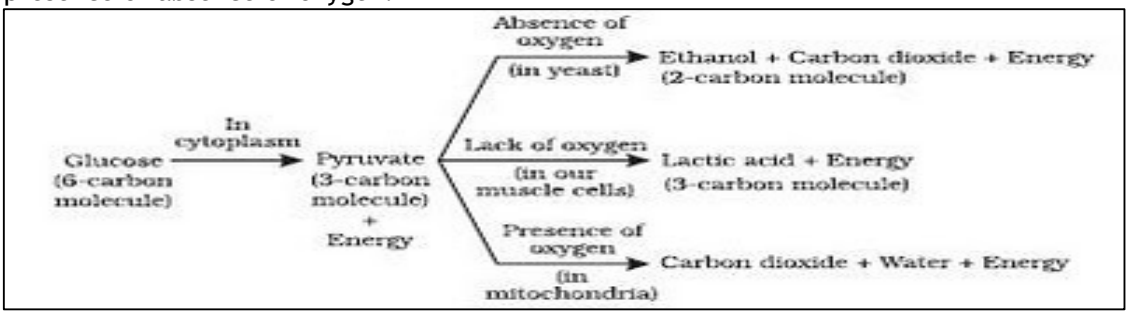
Difference between Breathing and Respiration

	Breathing	Respiration
1	Physical process of intake of fresh air/water (rich in oxygen) and giving out foul air/water (rich in carbon dioxide).	Biochemical process in which glucose is oxidized to CO_2 and H_2O along with exchange of gases.
2	No energy is released in this process.	Energy is released in this process.
3	Enzymes are not involved in. breathing.	Enzymes are involved in respiration.
4	Occur in lungs.	Occur in each and every cell of body.

Anaerobic Respiration: 'Partial oxidation of food in the absence of oxygen, resulting in the release of some amount of energy, is called anaerobic respiration'. Anaerobic respiration means in the absence of oxygen; while aerobic means in the presence of oxygen.

- Glucose has six carbon atoms joined to each other by covalent bonds. Hydrogen and oxygen atoms are also attached to these carbon atoms. In anaerobic respiration of glucose, some hydrogen atoms are removed, resulting in its oxidation. At the end of a series of reaction, glucose gets converted into two molecules of **pyruvate,** which contains three carbon atoms.
- 'The oxidation of glucose in a series of reactions leading to the formation of pyruvate is called glycolysis.'

• Glycolysis means 'splitting of sugar'. It takes place in all organisms, in the cytoplasm of the cell. It is the first stage of respiration – both aerobic and anaerobic. After glycolysis, its product (pyruvate) gets converted into different compounds depending on the presence or absence of oxygen.

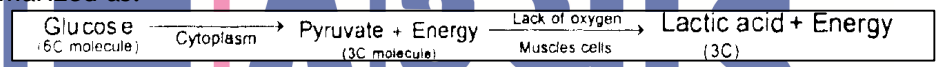


• After glycolysis, further anaerobic reactions produce different products like lactic acid or ethanol (ethyl alcohol) in different situation. This step completes the anaerobic respiration of glucose. Anaerobic respiration resulting in the formation of lactic acid and ethanol is called 'fermentation'. Examples are: lactic acid fermentation and alcohol fermentation.

1. **Lactic acid fermentation**:

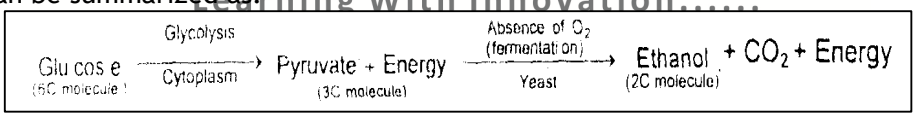
The process of incomplete breakdown of sugar into lactic acid and energy in some bacteria, e.g. in yogurt making, some bacteria cause milk to turn sour. These bacteria feed on sugar and break it into lactic acid.

In our muscles, after vigorous physical exercise, glucose is metabolized to form lactic acid. The accumulation of lactic acid causes fatigue and muscle cramps after prolonged can be summarized as:



2. **Alcoholic fermentation**:

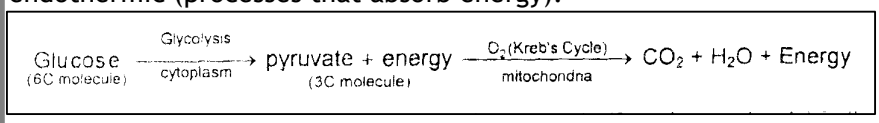
The incomplete breakdown of sugar into ethanol and carbon dioxide to release energy. This process occurs mainly in yeast, which is used to produce beer, wine, cheese etc by brewing. It can be summarized as:



Aerobic respiration'The complete oxidation of food yielding carbon dioxide, water and energy in the presence of oxygen is called aerobic respiration.' This respiration takes place inside the mitochondria. The products of this reaction include: ATTP, carbon dioxide and water. The number of molecules of ATP formed anaerobic respiration is 38. Hence, the energy made available is much greater than in the case of anaerobic respiration.

Inside the mitochondria, when an inorganic phosphate group (PO_4^{3-}, represented as Pi) gets attached to a compound called ADP (adenosine diphosphate), a molecule of ATP is formed: **ADP + Pi + energy → ATP**

The bond holding the last phosphate group is easily broken when ATP reacts with water. In the process, energy is produced. This energy is used to drive cellular processes that are endothermic (processes that absorb energy).



Difference between Aerobic and Anaerobic Respiration

	Aerobic Respiration	Anaerobic Respiration
1	It takes place in the presence of	It takes place in the absence of oxygen.

	oxygen.	
2	The first step in this process (glycolysis) takes place in the cytoplasm, while second step takes place in the mitochondria.	The complete process takes place in the cytoplasm.
3	Glucose is completely oxidized into carbon dioxide, water and energy.	Glucose if incompletely oxidized either into carbon dioxide, ethyl alcohol and energy (as in yeast) or into lactic acid and energy (as in muscle cell)
4	38 molecules of ATP are produced by the complete oxidation of one gram mole of glucose	Only 2 molecules of ATP are formed in this process

Exercise 1

Q1. What are respiratory substrates? Give one example and write the equation.
Q2. Where does aerobic respiration occurs? How many molecules of ATP are released during it?
Q3. After prolonged exercise, we often develop muscle cramps and fatigue in body. Why?
Q4. State the function of ATP.
Q5. Where does anaerobic respiration occur?

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