Difference Between Aerobic and Anaerobic respiration

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Difference Between Aerobic and Anaerobic Respiration

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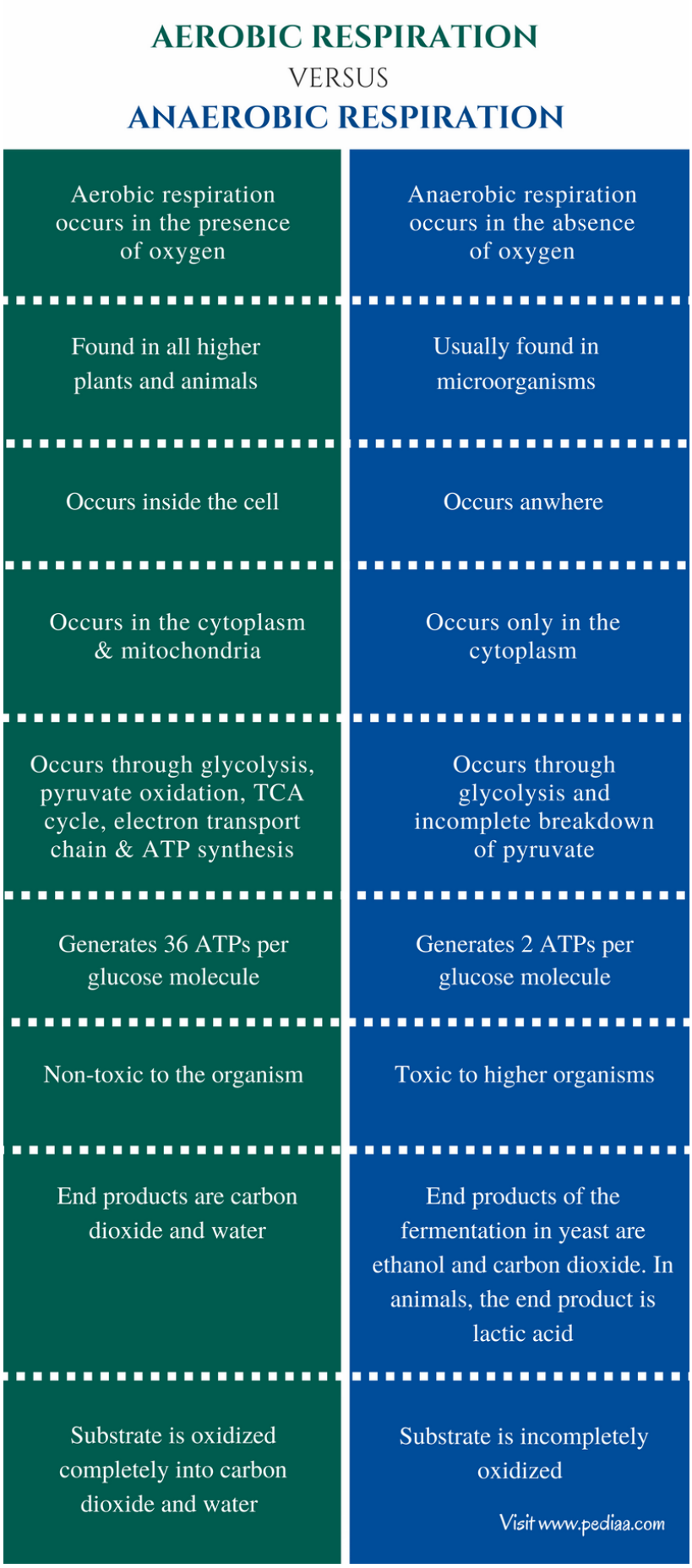
Main Difference – Aerobic vs Anaerobic Respiration

Aerobic and anaerobic respiration are the two types of cellular respiration found in organisms. Cellular respiration is the process of degrading food in order to release the potential energy in the form of ATP. Aerobic respiration occurs in higher animals and plants. Anaerobic respiration mainly occurs in microorganisms like yeast. Both processes use glucose as the raw material. The **main difference** between aerobic and anaerobic respiration is that **aerobic respiration occurs in the presence of oxygen** whereas **aerobic respiration occurs in the absence of oxygen**.

This article examines,


AEROBIC RESPIRATION
VERSUS
ANAEROBIC RESPIRATION
Aerobic respiration occurs in the presence of oxygen
Anaerobic respiration occurs in the absence of oxygen
Found in all higher plants and animals
Usually found in microorganisms
Occurs inside the cell
Occurs anwhere
Occurs in the cytoplasm & mitochondria
Occurs only in the cytoplasm
Occurs through glycolysis, pyruvate oxidation, TCA cycle, electron transport chain & ATP synthesis
Occurs through glycolysis and incomplete breakdown of pyruvate
Generates 36 ATPs per glucose molecule
Generates 2 ATPs per glucose molecule
Non-toxic to the organism
Toxic to higher organisms
End products are carbon dioxide and water
End products of the fermentation in yeast are ethanol and carbon dioxide. In animals, the end product is lactic acid
Substrate is oxidized completely into carbon dioxide and water
Substrate is incompletely oxidized
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What is Aerobic Respiration

The set of reactions occurring in the presence of oxygen, which breaks down food in order to generate energy in the form of ATP, is known as aerobic respiration. The most abundant type of cellular reparation is aerobic respiration, which occurs in higher plants and animals. Aerobic respiration occurs in the cytoplasm as well as in the mitochondria. It produces 36 ATP from a single glucose molecule. Basically, three steps are involved in aerobic respiration. They are glycolysis, citric acid cycle and the electron transport chain. The substrate is mostly glucose and the inorganic end products are carbon dioxide and water. Hence, aerobic respiration is the reverse of photosynthesis. The overall chemical reaction of aerobic respiration is shown below.

Chemical Reaction of Aerobic Respiration

$$C_6H_{12}O_6 + 6\mathbf{O}_2 \rightarrow 6CO_2 + 6H_2O + 2{,}900\ \text{kJ/mol}$$

Glycolysis is the first step of aerobic respiration and occurs independently without oxygen. Therefore, it is the first step of glucose degradation in anaerobic respiration as well. Glycolysis occurs in the cytoplasm of all cells. During glycolysis, glucose is broken down into two pyruvate molecules, generating 2 ATPs as the net gain. In addition, two molecules of NADH are formed by obtaining electrons from glyceraldehyde-3-phosphate. The pyruvate is transformed into the matrix of mitochondria, forming acetyl-CoA from pyruvate by eliminating carbon dioxide during oxidative decarboxylation of pyruvate. Acetyl-CoA then enters into the **citric acid cycle**, which is also called the Krebs cycle. During the citric acid cycle, a single glucose molecule is completely oxidized into six carbon dioxide molecules, generating 2 GTPs, 6 NADH and 2 $FADH_2$. These NADH and FADH2 are combined with oxygen, generating ATP during oxidative phosphorylation. The oxidative phosphorylation occurs in the inner membrane of mitochondria, transferring electrons through a series of carriers in the **electron transport chain**. The total yield of aerobic respiration is 36 ATP. A schematic diagram of aerobic respiration is shown in *figure 1*.

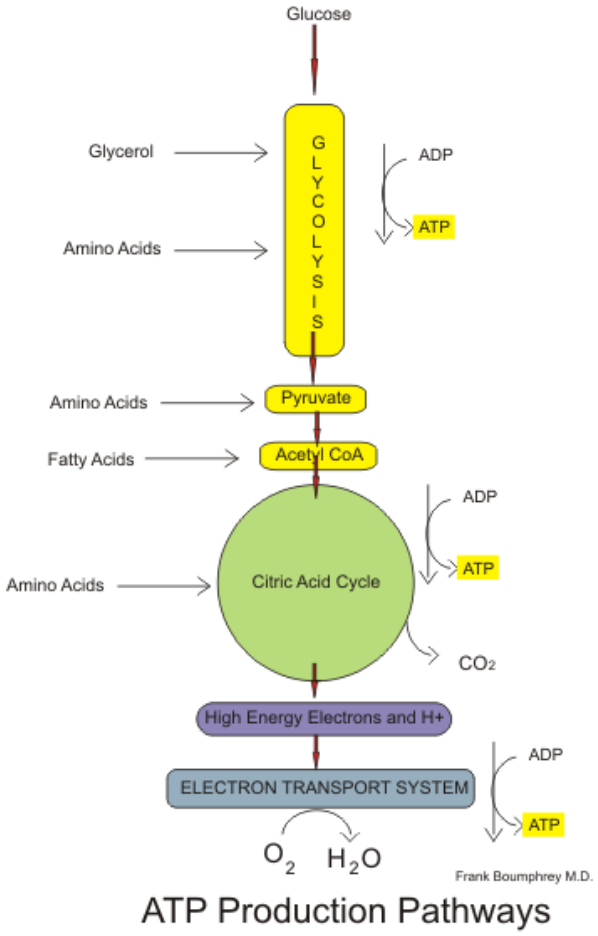

Figure 1: Aerobic Respiration

What is Anaerobic Respiration

Anaerobic Respiration is the set of reactions occurring in the absence of oxygen, which breaks down food into simple organic compounds, generating energy in the form of ATP. Anaerobic respiration occurs in microorganisms like some bacteria, yeast, and parasitic worms. It occurs in the cytoplasm of those organisms' cells, yielding only 2 ATPs.

Two categories of aerobic respiration are identified. The first category of anaerobic respiration occurs through glycolysis and incomplete oxidation of pyruvate either into lactic acid or ethanol. The process is called fermentation. The final electron acceptor and the hydrogen acceptor is the simple organic end product. The end products are secreted into the medium as waste metabolites. During fermentation, glycolysis occurs as the first step. The ensuing pyruvate is converted into ethanol in yeast and some bacteria. In plants, when oxygen is absent, ethanol is produced by anaerobic respiration. This type of fermentation is called as ethanol fermentation. The overall chemical reaction of ethanol fermentation is shown below.

Chemical Reaction of Ethanol Fermentation

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 118\ kJ/mol$$

In animals, when oxygen is absent, lactic acid is produced by anaerobic respiration. This is called as lactic acid fermentation. The overall chemical reaction for lactic acid fermentation is shown below.

Chemical Reaction of Lactic Acid Fermentation

$$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3 + 120\ kJ/mol$$

The efficiency of fermentation is very low compared to aerobic respiration. Lactic acid, which is produced during the lactic acid fermentation is toxic to tissues. The difference between aerobic respiration and anaerobic respiration in the sense of lactic acid fermentation is shown in *figure 2*.

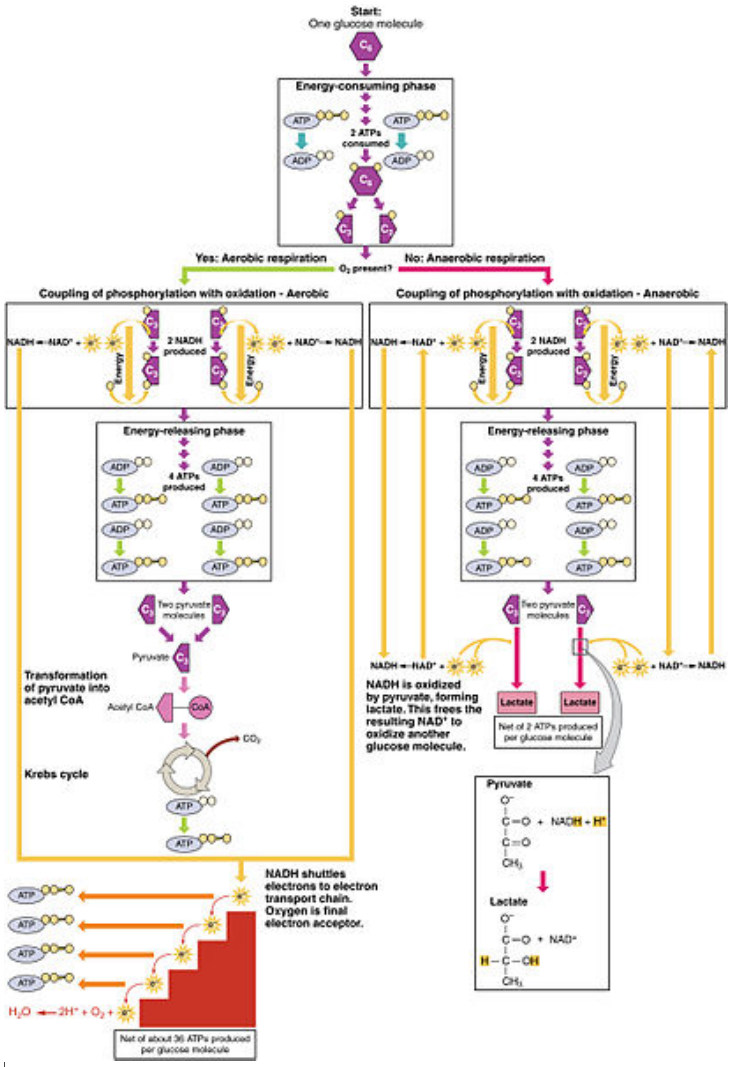

Figure 2: Difference between aerobic respiration and lactic acid fermentation

During the second category of anaerobic respiration, the final electron acceptor is sulfate or nitrate at the end of the electron transport chain. Some prokaryotes like bacteria and archaea perform this type of anaerobic respiration. Accepting electrons by sulfate produces hydrogen sulfide as the end product. In methanogens, the final electron acceptor is carbon dioxide, which produces methane as the end product.

Difference Between Aerobic and Anaerobic Respiration

Oxygen

Aerobic Respiration: Aerobic respiration occurs in the presence of oxygen.

Anaerobic Respiration: Anaerobic respiration occurs in the absence of oxygen.

Type of Plants and Animals

Aerobic Respiration: Aerobic respiration is found in all higher plants and animals.

Anaerobic Respiration: Anaerobic respiration is usually found in microorganisms, but rarely in higher organisms.

Occurrence

Aerobic Respiration: Aerobic respiration only occurs inside the cell.

Anaerobic Respiration: Anaerobic respiration can occur anywhere.

Localization inside Cell

Aerobic Respiration: Aerobic respiration occurs in the cytoplasm and mitochondria.

Anaerobic Respiration: Anaerobic respiration occurs only in the cytoplasm.

Permanent/Temporary Nature

Aerobic Respiration: Aerobic respiration occurs continuously in the presence of oxygen gas.

Anaerobic Respiration: Anaerobic respiration occurs continuously in microorganisms. But in higher animals, it occurs in the absence of oxygen.

Steps

Aerobic Respiration: Aerobic respiration occurs through glycolysis, pyruvate oxidation, TCA cycle, electron transport chain and ATP synthesis.

Anaerobic Respiration: Anaerobic respiration occurs through glycolysis and incomplete breakdown of pyruvate.

Efficiency

Aerobic Respiration: Aerobic respiration generates 36 ATPs per glucose molecule.

Anaerobic Respiration: Anaerobic respiration generates 2 ATPs per glucose molecule.

Toxicity

Aerobic Respiration: Aerobic respiration is non-toxic to the organism.

Anaerobic Respiration: Aerobic respiration is toxic to higher organisms.

End Products

Aerobic Respiration: End products in the aerobic respiration are carbon dioxide and water.

Anaerobic Respiration: End products of the fermentation in yeast are ethanol and carbon dioxide. In animals, the end product is lactic acid. Bacteria produce methane and hydrogen sulfide as end products.

Oxidization

Aerobic Respiration: Substrate is oxidized completely into carbon dioxide and water during aerobic respiration.

Anaerobic Respiration: Substrate is incompletely oxidized during anaerobic respiration.

Conclusion

Cellular respiration occurs in two pathways known as aerobic respiration and anaerobic respiration. Aerobic respiration mostly occurs in higher animals and plants. Anaerobic respiration occurs in microorganisms like parasitic worms, yeast, and some bacteria. Both aerobic and anaerobic respiration use glucose as the substrate. Aerobic respiration occurs in the presence of oxygen, completely oxidizing the substrate, yielding inorganic end products, carbon dioxide, and water. In contrast, anaerobic respiration occurs in the absence of oxygen, incompletely oxidizing the substrate, yielding organic end products like ethanol. Since anaerobic respiration incompletely oxidizes the substrate, the yield of ATP is very low compared to its yield of aerobic respiration. Aerobic respiration yields 36 ATPs but anaerobic respiration only yields 2 ATPs per glucose molecule. This is the difference between aerobic respiration and anaerobic respiration.

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About the Author: Lakna

Lakna, a graduate in Molecular Biology & Biochemistry, is a Molecular Biologist and has a broad and keen interest in the discovery of nature related things

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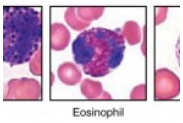

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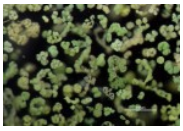

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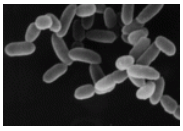

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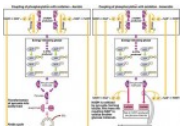

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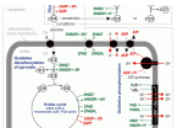

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