3 main differences between aerobic and anaerobic respiration

Both aerobic and anaerobic respiration uses the oxidation of organic molecules to synthesis ATPHowever there are several key differences between the two processes, including:Overall energy yieldProducts formedLocation of processesComparison of Anaerobic and Aerobic Respiration Overview of Anaerobic and Aerobic Pathways The process by which energy is released inside the cells due to the breaking of glucose molecules is called Cellular respiration. This process is further subdivided into 2 categories known as Aerobic and Anaerobic Respiration that is based on oxygen usage.Aerobic vs Anaerobic RespirationThe difference between Aerobic and Anaerobic Respiration is that the Aerobic respiration process is dependent on oxygen whereas the anaerobic respiration does not depend on oxygen for energy production. The process of cellular respiration either happens in the mitochondria or in the cytoplasm by either the Aerobic or the Anaerobic Respiration mechanism.Aerobic Respiration is the sub-category of cellular respiration that uses oxygen to produce energy from food. The term Aerobic is derived from the word Oxygen itself. The by-product of aerobic cellular respiration is carbon dioxide and Adenosine triphosphate (ATP).Anaerobic Respiration is the sub-category of cellular respiration that does not use oxygen to produce energy from food. The term Anaerobic is derived from the word Not Oxygen itself. The by-product of anaerobic cellular respiration is lactic acid and ATP. Keep in mind that ATP is the energy currency of all the cells.Anaerobic respirations use relatively less amount of energy as the glucose is not completely broken down as compared to aerobic cellular respiration due to the presence of oxygen in the process of respiration.Parameter of ComparisonAerobic RespirationAnaerobic RespirationDefinitionAerobic respiration involves energy production, by breaking down the glucose using oxygen.Anaerobic respiration involves energy production, by breaking down the glucose without using oxygen.Process DurationIt is a slow and time-consuming process.It is comparatively faster than the aerobic process.Combustion ProcessAerobic respiration has the complete combustion process.Anaerobic respiration has the incomplete combustion process.RequirementsIt involves the presence of oxygen and glucose for the process to take place.It involves the presence of only oxygen for the process to take place.End ProductsCarbon Dioxide and Water are produced as the byproducts of the process.Ethanol, Lactic acid and Carbon dioxide are produced as the byproducts.Amount of Energy ProductionIt involves a high amount of energy production due to the presence of oxygen to completely breakdown glucose.It involves a relatively low amount of energy production due to the absence of oxygen to completely breakdown glucose.EquationGlucose + Oxygen à Water + Energy + Carbon DioxideGlucose à Energy + Lactic AcidExamplesEukaryotes like plants and animals are common examples of Aerobic Respiration.Eukaryotes like those present in human muscle cells and bacteria, yeast etc. are common examples of Anaerobic Respiration.Aerobic Chemical Reaction is the enzyme-catalyzed chain reaction that involves breaking down glucose molecules to produce energy in the presence of oxygen.The end products of these chemical reactions yield byproducts like Carbon dioxide, water and a lot of energy. Around 2900 kJ/mol of glucose, is released as energy after this process.Chemical Equation for Aerobic RespirationGlucose + Oxygen → Carbon dioxide + Water + EnergyCarbon Dioxide and Water are produced as the byproducts of the process along with ATH i.e. Adenosine triphosphate. ATH drives energy to the cells to drive various processes like muscle movement or chemical synthesis etc.This chemical respiration is very common in animals and plants. If we see our breathing pattern, we inhale a lot of oxygen and in return exhale carbon dioxide.As the oxygen reaches different cells of the body that already contains glucose, which is then broken down to release carbon dioxide and water.This is utilized by our body and carbon dioxide is then released out to the atmosphere.Anaerobic Chemical Reaction is the enzyme-catalyzed chain reaction that involves breaking down glucose molecules to produce energy in the absence of oxygen.The end products of these chemical reactions yield byproducts like Carbon dioxide, Alcohol, and Energy.Chemical Equation for Anaerobic RespirationGlucose → Alcohol + Carbon dioxide + EnergyIn response to a shortage of oxygen to the human body, we humans tend to also exhibit anaerobic chemical respiration.While we are undergoing heavy-duty tasks like running, playing, sprinting or exercising, our body requires a lot of extra energy.This extra energy demand is fulfilled by our muscle cells by undergoing an anaerobic respiration process.In case you ever have a muscle cramp while playing or exercising, then you know who you have to blame now.Due to lack of oxygen, the glucose breakdown is not complete which might result is the development of lactic acid as a byproduct.Glucose → Lactic acid + EnergyThus, we can say that the anaerobic respiration produces relatives lower amount of energy compared to aerobic respiration due to lack of oxygen in the process.Although both are methods of energy generation via chemical respiration there exist a lot of differences between Aerobic and Anaerobic Respiration when it comes to oxygen usage and energy production. Aerobic respiration involves the usage of oxygen to breakdown glucose while anaerobic respiration involves the absence of oxygen to breakdown glucose and produce energy.Anaerobic respiration only occurs in the cytoplasm whereas the anaerobic chemical respiration occurs in cytoplasm and mitochondria.Anaerobic chemical respiration involves very less amount of energy production in ATPs when compared to Aerobic respiration.Incomplete Combustion process occurs in anaerobic respiration whereas complete combustion is observable in Aerobic Respiration.Both processes i.e. Aerobic and Anaerobic Respiration are important for all living beings to survive as the respiration process is crucial for the existence of life on earth.The energy requirements of various livings beings are fulfilled by these two Chemical Respiration processes.While Aerobic chemical respiration encompasses the use of oxygen to break glucose and produce energy. On the other hand, anaerobic respiration involves the absence of oxygen to break glucose and produce energy.Also, anaerobic chemical respiration involves less energy production due to a lack of oxygen to break down glucose completely.However, this can be really crucial in cases where oxygen supply is very limited.But all in all both Aerobic and Anaerobic Respiration processes are great ways for humans and all living beings to survive as chemical respiration is decisive for existence. 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, 1. What is Aerobic Respiration – Characteristics, Process 2. What is Anaerobic Respiration – Characteristics, Process 3. What is the difference between Aerobic and Anaerobic Respiration 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 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2{,}900$ 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 $FADH_2$ 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 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. 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. Reference:1. Cooper, Geoffrey M. "Metabolic Energy." The Cell: A Molecular Approach. 2nd edition. U.S. National Library of Medicine, 01 Jan. 1970. Web. 07 Apr. 2017.2. Jurtshuk, Peter, and Jr. "Bacterial Metabolism." Medical Microbiology. 4th edition. U.S. National Library of Medicine, 01 Jan. 1996. Web. 07 Apr. 2017.3. "Aerobic Respiration and Anaerobic Respiration – Pass My Exams: Easy exam revision notes for GSCE Biology." Aerobic Respiration and Anaerobic Respiration – Pass My Exams: Easy exam revision notes for GSCE Biology. N.p., n.d. Web. 07 Apr. 2017. Image Courtesy:1. "Aerobic pathways" By Boumphreyfr – Own work (CC BY-SA 3.0) via Commons Wikimedia2. "2505 Aerobic Versus Anaerobic Respiration" By OpenStax College – Anatomy & Physiology, Connexions Web site. Jun 19, 2013. 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