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Together, the processes of photosynthesis and cellular respiration allow life on Earth to gather energy for use in other reactions. Besides the organisms that rely on sulfur near hydrothermal vents, the majority of life on Earth relies on the sugar glucose. Glucose is created by the process of photosynthesis. Cellular respiration involves the breakdown of glucose and the storage of the energy received into the molecule ATP. Plants create their own energy through photosynthesis and also use cellular respiration to produce ATP. Animals must rely on the sugars that they've gathered from plants to supply their mitochondria material to produce ATP. Photosynthesis is the main process which drives life on Earth. Through photosynthesis, energy from the sun is captured in the bonds of organic molecules. These molecules, glucose molecules, are the basis of all life on Earth. Glucose will be used by the process of cellular respiration to harness chemical energy stored within the covalent bonds of the sugar. Photosynthesis occurs in the leaves and green parts of plants. Organelles within plant cells, known as chloroplasts, contain specialized proteins capable of interacting with light. Cytochromes are these specialized proteins, which are attached to a heme group. Heme groups are also seen bound to hemoglobin, in blood cells. Instead of iron, these heme cells bind magnesium. The complex structure of the heme interacts with the photons of light passing through them. The chloroplast uses the energy harnessed from these photons and their interaction with the cytochromes and other proteins to drive the formation of glucose. To do this, the chloroplasts will combine units of carbon dioxide into chains of 6 carbons, 12 hydrogens, and 6 oxygens. This is glucose, which can then be modified and combined with other glucose molecules to be stored as starches and complex sugars like fructose. The photosynthesis reaction has two parts, commonly referred to as the Light reactions and the Calvin Cycle. The entire process of photosynthesis can be seen below. Simple photosynthesis overview At the top of the diagram, light and water combine in the chloroplasts, where the hydrogens are separated from the oxygen in chain of proteins starting from the energy-collecting cytochromes and accessory pigments. The hydrogens, electrons, and associated energy are bound to ADP and NADP+. These molecules can bind a hydrogen, electrons, and energy. In doing so, they become the main products of the light reactions, NADPH and ATP. Oxygen is produced as a by-product. ATP and NADPH are then used within the Calvin Cycle, a series of reactions which recycles these electron-carriers and produces glucose. The energy within and the hydrogen molecules are used to energize reactions throughout the cycle. The Calvin Cycle has three phases, carbon fixation, reduction, and regeneration of ribose. These reactions can be seen in the image below. Notice that the addition of one carbon dioxide in one turn of the reaction produces the 3-carbon molecule 3-phoshphoglycerate. Two of these molecules are then combined to produce a glucose, among other things. Calvin cycle Once the glucose is created by the chloroplasts, it can be used to drive other reactions within the cell. It can also be exported to other cells within the organism. This is where the process of cellular respiration takes over. Cellular respiration has 4 distinct processes, which drive the creation of ATP. This ATP can be used in a number of cellular reactions, and provides activation energy to help enzymes complete tasks. Cellular respiration happens in the mitochondria, a small organelle similar to the chloroplasts. While chloroplasts are only found in plants, mitochondria are found in all living eukaryotes. Plants provide all the glucose their cells need, and more. This extra glucose they store as starches and complex sugars. Animals, and indeed the entire food-chain, relies on the glucose produced by plants. The first process of cellular respiration, glycolysis, is exactly what its name implies. "Glyco-" refers to glucose, where "-lysis" refers to something being divided or split in half. Glycolysis happens within the cytosol of the cell, outside of the mitochondria. In this process, the 6-carbon glucose molecule is split into two molecules of pyruvate. This 3-carbon molecules is then converted to Acetyl CoA in the next step. This molecule will be an essential part of the Krebs cycle. Acetyl CoA is also able to transfer into the mitochondria, where the Krebs cycle and oxidative phosphorylation will take place. This can be seen in the diagram below. The labels on the right show where the various reactions take place. Cellular Respiration The Krebs cycle is similar to the Calvin cycle, in that it recycles certain molecules to continually drive the production of electrons and ATP. The electrons are then passed to the inner mitochondrial membrane. This membrane is loaded with specialized proteins, capable of transferring energy derived from the passing of electrons down their potential gradient. This electron transport chain uses a series of electron driven enzymes, which specialize in binding loose phosphate groups to ADP. In doing so, they store energy in the bond between these molecules, and create an ATP. These ATP molecules are then exported from the mitochondria, and can be used throughout the cell to provide energy in other reactions. For instance, ATP is used to pump ions out of cells, creating the electrical potential needed for nervous reactions. There are innumerous other examples. In the Theory of Evolution, the origins of life on Earth are highly unproven. However, there is a large body of evidence which points to the fact that all life has a common ancestor. This ancestor then diverged, over hundreds of millions of years, into the millions of species we see on Earth today. The process of endosymbiosis would account for this complexity. Bacteria, the simplest organisms, likely represent a fairly unchanged version of the first form of life. Bacteria have no organelles, and complete all the reactions they need for metabolism within a single compartment. Many bacteria are able to complete glycolysis, which can provide them with energy. Others are able to photosynthesize, like primitive single-celled plants. According to Endosymbiotic theory, these ancient bacteria began interacting and the processes of evolution drove them into different niches within the environment. Some would harness sunlight, while others would feed upon those. Eventually, some of the predatory bacteria became quite large. As such, they could take in large quantities of smaller bacteria. Instead of digesting them, they created a safe space for them and helped them produce more energy. Thus, the smaller endosymbiotic bacteria became the first organelles. This theory suggests that chloroplasts were originally photosynthetic bacteria, and that mitochondria were originally bacteria capable of oxidative phosphorylation. The larger bacteria became eukaryotes, and developed other organelles. This theory is backed by the evidence that both chloroplasts and mitochondria are surrounded in double membranes, a supposed remnant of the ancestral engulfing process. Further, both mitochondria and chloroplast contain bits of circular DNA, similar to that found in bacteria. This DNA is replicated separately from the main DNA found within the nucleus. Hundreds of millions of years after this division of organelles, and evolution has given us what we see today. Plants are related to algae, which are related to photosynthetic bacteria. Animals are related to the ancient organisms which did not receive photosynthetic endosymbionts, and instead relied on consuming other organisms. At the bottom of the food-chain sit the photosynthetic organisms. They form by far the largest biomass on Earth, limited only by the amount of sunlight, nutrients, and water they receive. One step above plants and algae, herbivores exploit the bounty that plants produce. Some of the largest animals in the world, such as the elephant, are entirely herbivorous. But, there are herbivores of every size, all the way down to grasshoppers and tiny insects. Because an herbivore must consume many photosynthetic organisms to grow, there are many less organisms on this level of the food-chain. Likewise, there are many less carnivores than there are herbivores, because they must feed on many smaller organisms throughout their life to grow and reproduce. In this way, the entire food-chain and ecology in general is entirely based off of the processes of photosynthesis and cellular respiration. Ecology is also the study of how various organisms interact with each other while carrying out these reactions. 1. Which of the following is NOT a difference between photosynthesis and cellular respiration A. Only one uses sunlight B. Only one breaks glucose down C. Only one relies on a cycle of carbon molecules C is correct. The Krebs cycle and the Calvin cycle, while differing in their outputs, both rely on a chain of carbon molecules which are continually recycled. The molecules are different, but the processes are very similar. 2. As a human, your cells rely on glucose to function. Where does this glucose come from? A. Your body B. Plants C. Meat B is correct. All of the food that you consume was at one point a plant. If you eat meat, the nutrients you receive from that meat are the same nutrients that animal ate before it died. Even the protein and fat in animals is simply a reuse of the protein and glucose found in plants. 3. Which of the following things would be MOST devastating to an ecosystem? A. All the grass in a meadow is killed with an herbicide. B. All the butterflies in a meadow are killed with a pesticide. C. All the birds in a meadow are killed by hunters. A is correct. Without the grass, the entire food chain will collapse. The other two examples represent higher levels of the food chain. Without grass, all the insects would die, and all the birds. But also remember that none of the options are good. Without the birds, insects may eat all the grass and the same result will occur. References Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., . . . Matsudaira, P. (2008). Molecular Cell Biology (6th ed.). New York: W.H. Freeman and Company. McMahon, M. J., Kofranek, A. M., & Rubatzky, V. E. (2011). Plant Science: Growth, Development, and Utilization of Cultivated Plants (5th ed.). Boston: Prentince Hall. Nelson, D. L., & Cox, M. M. (2008). Principles of Biochemistry. New York: W.H. Freeman and Company. In order to continue enjoying our site, we ask that you confirm your identity as a human. Thank you very much for your cooperation. Photosynthesis and cellular respiration are complementary biochemical reactions. Photosynthesis requires the products of respiration, while respiration requires the products of photosynthesis. Together these reactions allow cells to make and store energy and help regulate atmospheric concentrations of carbon dioxide and oxygen. Only autotrophic organisms like plants, algae and some bacteria can perform photosynthesis, while most organisms perform respiration. Autotrophic organisms perform both photosynthesis and respiration. During photosynthesis light energy from the sun causes carbon dioxide and water to be transformed into glucose (sugar) and oxygen. (See reference 2 page 107) Respiration requires glucose and oxygen to make carbon dioxide and water. In the process, chemical energy in the form of adenosine triphosphate (ATP) is released. ATP is the form of chemical energy all cells require to perform the functions necessary to life. Photosynthesis releases oxygen into the atmosphere and absorbs carbon dioxide. Respiration requires oxygen to allow cells to make ATP. Respiration can also occur in yeast or bacteria in the absence of oxygen, and this process is called fermentation. Fermentation is the process that produces beer, wine, yogurt, soy sauce and other food products. Biology: Concepts and Connections; Neil A. Campbell; 2009 Fermentation Veloz, Liz. "How Are Photosynthesis & Cellular Respiration Related?" sciencing.com, . 14 October 2009. APA Veloz, Liz. (2009, October 14). How Are Photosynthesis & Cellular Respiration Related?. sciencing.com. Retrieved from Chicago Veloz, Liz. How Are Photosynthesis & Cellular Respiration Related? last modified March 24, 2022. Photosynthesis and respiration are two fundamental processes that occur in living organisms. Photosynthesis is the process by which plants, algae, and some bacteria convert sunlight into chemical energy in the form of glucose. Respiration is the process by which all living cells release energy from glucose and convert it into a form that cells can use for their activities. Although these processes may seem opposite, they share some similarities. Both involve the transfer of electrons, use enzymes to facilitate reactions, and occur in organelles (chloroplasts and mitochondria). Understanding the differences and similarities between these processes is crucial to understanding the bioenergetics of life. Differences and Similarities between Photosynthesis and Respiration.ParameterPhotosynthesisRespiration OccurrenceOnly occurs in phototrophs (all green plants, algae and some bacteria).Occurs in all living organism. By-product The by- product are oxygen, glucose and water.The by-products include carbon dioxide, water, and energy (ATP).Reactants The reactants in the photosynthetic process include carbon dioxide, water, and light energy.The reactants of respiration are glucose and oxygen.Location Photosynthesis takes place in chloroplasts.Respiration takes place in mitochondria.Reactions Photosynthesis is an endothermic reaction as it requires energy.When energy is released during respiration, it is an exergonic process.FunctionPhotosynthesis produce food and captures the energy.Respiration takes in oxygen and release out carbon dioxide. SunlightIt requires the presence of sunlight.It does not require the presence of sunlight and continues to occur day and night.Co2 and water Absorb carbon dioxide and water. Release carbon dioxide and water. Chemical reaction The chemical reaction of photosynthesis is 6CO2 + 6H2O → C6H12O6+ 6O2.The chemical reaction of cellular Respiration is C6H12O6+ 6O2 → 6CO2 + 6H2O.Electrons carriersNADPH carries electrons in photosynthesis.NADH and FADH2 carries electrons in cell respiration.Proton movementProton are pumped into thylakoid space of chloroplast.Proton are pumped into inner membrane space of the mitochondria.Differences and Similarities between Photosynthesis and RespirationThe products of one system are the reactants of the other because of the way that photosynthesis and cellular respiration are related. In order to create glucose and oxygen, photosynthesis uses the energy from sunlight, water, and carbon dioxide. Oxygen and glucose are used in cellular respiration to create carbon dioxide and water.The cycle of cellular respiration and photosynthesis is essential for the life of humans, animals, and plants. Humans and other animals breathe in oxygen that plants make during photosynthesis so that the blood may carry it to the cells where it is used for respiration. Plants absorb the carbon dioxide that is emitted from the body during breathing and uses it to help their growth and development. This never-ending cycle is what keeps life on earth going.Fig: Relationship between photosynthesis and respirationPlants and other photosynthetic organisms create energy through the process of photosynthesis, whereas cellular respiration converts the energy into a usable form. These two processes have certain commonalities despite the differences between them. For instance, ATP, the unit of energy, is produced and used by both processes.Learn MorePhotosynthesis: Factors Affecting It and Its Different TypesEnergy is produced during both the photosynthesis and respiration processes.Both photosynthesis and respiration produce and makes use of ATP.Glycogen-3- phosphate is formed in both processes i.e., glycolysis in respiration and Calvin cycle in photosynthesis.Both utilize electron transport change to produce ATP.Both processes can observe emergent properties in multiple steps.Both respiration and photosynthesis utilize cycle where starting materials is generated after molecules leaves the cycle.Both processes involve exchange of gases.Differences and Similarities between Photosynthesis and Respiration Cellular Respiration and Photosynthesis Loading... Found a content error? Tell us Both cellular respiration and photosynthesis are parts of a mutually beneficial relationship. Photosynthesis cannot occur without cellular respiration and cellular respiration certainly cannot occur without photosynthesis. Photosynthesis and cellular respiration are in many respects the "reverse" of one another. Photosynthesis is an anabolic process, whereas cellular respiration is a catabolic process. Let us explore more differences between cellular respiration and photosynthesis Photosynthesis and cellular respiration are the two essential life processes on Earth that help living organisms survive. They are interrelated such that the products of one process are the reactants of the other and thus work in a cycle. Photosynthesis and Cellular Respiration Photosynthesis is a process by which green plants and algae make food in the form of carbohydrates (C6H12O6) using water (H2O), carbon dioxide (CO2), and chlorophyll in the presence of sunlight as the energy source. Water and oxygen are produced as byproducts. In contrast, cellular respiration breaks down carbohydrates produced through photosynthesis and uses oxygen to produce energy and carbon dioxide. The carbon dioxide is again utilized during photosynthesis to continue the cycle. The relationship between photosynthesis and cellular respiration can be best understood using the chemical equations given below: Equations Photosynthesis: 6CO2 + 12H2O + sunlight → C6H12O6 + 6O2 + 6H2O Cellular Respiration: C6H12O6 + 6O2 → 6CO2 + 6H2O + ATP (energy) Thus, photosynthesis is just the opposite process of cellular respiration, and they work in a circle. Both processes are essential parts of the carbon cycle. While cellular respiration produces carbon dioxide in the environment, photosynthesis removes carbon dioxide from the atmosphere. The exchange of CO2 and O2 during photosynthesis and cellular respiration helps recycle carbon dioxide in the biosphere. It keeps oxygen and carbon dioxide levels stable. Although interrelated in nature, photosynthesis and cellular respiration are different in many ways. BasisPhotosynthesisCellular Respiration1. LocationThe process occurs in the chloroplastThe process occurs in mitochondria2. Inputs (Reactants)Carbon dioxide (CO2), water (H2O), and sunlightGlucose and oxygen3. Output (Products)Oxygen (O2) and glucose (C6H12O6)Water and carbon dioxide4. Steps of the PathwayIt occurs in two stages:1) Light-dependent Step – Chlorophyll converts solar energy to chemical energy stored as NADPH and ATP. It takes place in the thylakoid membrane within the chloroplast2) Light-independent Step or Calvin Cycle – It takes place in the stroma of the chloroplast. Here, the CO2 uses the chemical energy harvested during the light-dependent stage to produce GA3P (glyceraldehyde-3-phosphate), which finally forms glucoseIt occurs in four stages:1) Glycolysis – Here, glucose gets converted into two pyruvate molecules. In the end, ATP is produced, and NAD+ is converted into NADH2) Pyruvate Oxidation – Each pyruvate from the previous step enters the mitochondrial matrix, which is converted to acetyl CoA. Consequently, carbon dioxide is released, and NADH is generated3) Citric acid cycle or Krebs cycle – The acetyl CoA combines with a four-carbon molecule. It undergoes a cycle of reactions, regenerating the four-carbon starting molecule. In the end, ATP, NADH, and 2FADH2 are produced, and carbon dioxide is released4) Oxidative phosphorylation – The NADH and FADH2 formed in the citric acid cycle turn into NAD+ and FAD+ by transferring their electrons to the electron transport chain (ETC). At the end of ETC, the O2 gets converted into water 5. Net ATP ProductionProduce 2 ATP molecules during synthesis of one molecule of glucoseProduce 38 ATP molecules during the oxidation of one molecule of glucose6. FunctionsProvides the source of energy for all organisms on EarthReleases the stored energy by breaking down the carbohydrate produced through photosynthesis7. Occurs inOccurs only in photoautotrophs (all green plants, some photosynthetic bacteria, and algae)It occurs in every living organism8. Type of ProcessAnabolic processCatabolic process9. Energy Required or ReleasedIt is an endothermic reaction. So, it requires solar energyIt is an exothermic reaction. So, it releases energy in the form of ATP10. Presence or Absence of SunlightIt occurs only in the presence of sunlightIt does not require sunlight and thus occurs all the time11. What Powers ATP SynthaseA gradient caused due to high H+ concentration in the thylakoid lumen powers ATP synthaseA gradient caused due to high H+ concentration in the intermembrane space of mitochondria powers ATP synthase12. What Pumps Protons Across the MembraneDuring cyclic phosphorylation, the flow of electrons through cytochrome bf complex pumps protons into the thylakoid lumenComplexes I, III, and IV of the electron transport chain act as proton pumps. These complexes capture the energy released by electrons moving downhill and pump out H+ ions from the inner mitochondrial matrix to the intermembrane space13. Electron SourcePhotolysis of H2OGlucose, NADH+, FADH214. Final Electron AcceptorNADP+ (forms NADPH)O2 (forms H2O)15. Coenzymes usedNADP+, the oxidized state of nicotinamide adenine dinucleotide phosphate (NADP)NAD+, the oxidized state of nicotinamide adenine dinucleotide (NAD) Despite the two processes being opposite, they share some similarities. They involve multiple complex steps and many same molecules such as oxygen (O2), carbon dioxide (CO2), water (H2O), glucose (C6H12O6), and adenosine triphosphate (ATP)Exchange of gasesSeries of redox reactions involving enzymes Photosynthesis and cellular respiration are the two basic metabolic processes that work together to drive all cellular activities. All the primary producers in a food chain produce food by photosynthesis. In contrast, cellular respiration occurs in all living organisms on Earth. Food gets oxidized to obtain energy as ATP, which powers almost all the cellular processes. Also, the products of one process are utilized by another, creating a balance in nature. Q1. What role does oxygen play in photosynthesis and cellular respiration? Ans. Oxygen is released as a byproduct in photosynthesis, whereas, in cellular respiration, oxygen helps to oxidize glucose to liberate energy. Article was last reviewed on Wednesday, August 31, 2022

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