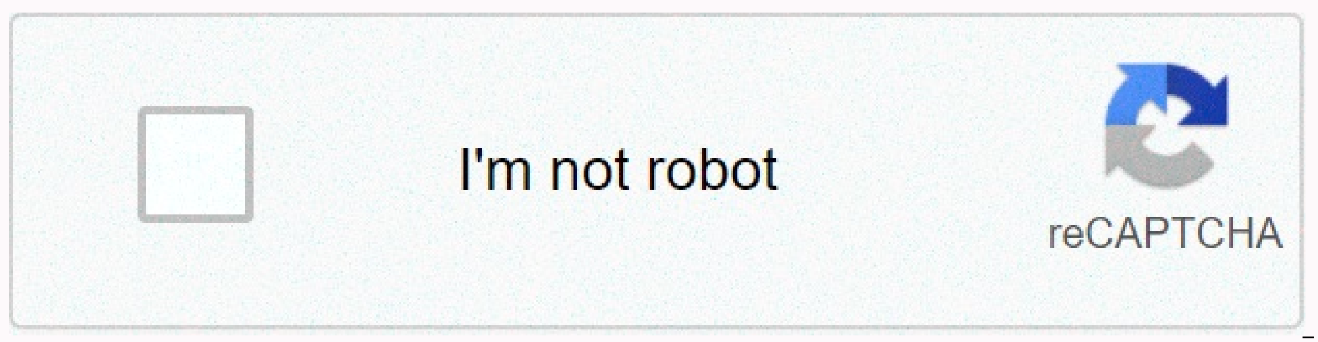

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Oxidative phosphorylation worksheet pogil

Pogil Key PDF Oxidative Phosphorylation Download Redirect After Seconds In this section, you will explore the following questions: How do electrons move through the electron transport chain and what happens to their energy levels? How is a proton gradient (H+) established and maintained by the electron transport chain and how many ATP molecules are produced by chemiosmosis? The electron transport chain (ETC) is the stage of aerobic respiration that uses free oxygen as the ultimate acceptor of electrons from electrons removed during glucose metabolism in glycolysis and citric acid cycle. ETC is located on the membrane of the mitochondrial cristae, an area with many folds that increase the surface area available for chemical reactions. Electrons transported by NADH and FADH2 are delivered to electron-accepting proteins embedded in the membrane as they move toward the final electron acceptor, O2, forming water. Electrons undergo a series of redox reactions, using free energy at three points to transport hydrogen ions through the membrane. This process contributes to the formation of the H+ gradient used in chemiosmosis. As protons are pushed down their concentration gradient through ATP synthesizer, ATP is generated from ADP and inorganic phosphate. In aerobic conditions, the stages of cellular respiration can generate 36-38 ATP. Information presented and the examples highlighted in the support concepts section described in The Big Idea 2 of the Ap® Biology Curriculum Framework, as shown in the table. As shown in the table, the concepts covered in this section also align with the Learning Objectives listed in the Curriculum Framework that provide a transparent basis for the ap® Biology course, a survey-based laboratory experiment, instructional activities, and ap® examination questions. A Learning Objective merges required content with one or more of the seven Scientific Practices. Introduce oxidative phosphorylation using visuals like this video. That students create a visual representation that shows an overview of glycolysis and citric acid cycle and how cycles relate to each other. An example is illustrated here. The Scientific Practice Challenge Questions contain additional test questions for this section that will help you prepare for the AP exam. These questions address the following norms: [APLO 2.5][APLO 2.15][APLO 2.18][APLO 2.22]You just read about two-way Introduce glucose catabolism —glycolysis and citric acid cycle—that generate ATP. Most of the ATP generated during aerobic glucose catabolism, however, is not generated directly from these pathways. Instead, it is derived from a process that begins with moving electrons through a series of transporters electrons that suffer redox reactions. This causes hydrogen ions to accumulate within the intermembrane space. Therefore, a concentration concentration forms in which hydrogen ions diffuse from the intermembrane space to the mitochondrial matrix through atp synthase. The current of hydrogen ions feeds the catalytic action of ATP synthase, which phosphoryla ADP, producing ATP. The electron transport chain (Figure 7.11) is the last component of aerobic respiration and is the only part of glucose metabolism that uses atmospheric oxygen. Oxygen spreads continuously in plants; in animals, it enters the body through the respiratory system. Electron transport is a series of redox reactions that resemble a shuttle race or bucket brigade in which electrons are rapidly passed from one component to another, to the end point of the chain where electrons reduce molecular oxygen, producing water. There are four protein compound complexes, labeled I to IV in Figure 7.11, and the aggregation of these four complexes, together with mobile electron carriers and associated accessories, is called the electron transport chain. The electron transport chain is present in multiple copies of the internal mitochondrial membrane of eukaryotes and in the plasma membrane of prokaryotes. Figure 7.11 The electron transport chain is a series of electron transporters embedded in the internal mitochondrial membrane that transports electrons from NADH and FADH2 to molecular oxygen. In the process, protons are pumped from the mitochondrial matrix into the intermembrane space, and oxygen is reduced to form water. For starters, two electrons are transported to the first complex aboard the NADH. This complex, labeled I, is composed of flavin mononucleotide (FMN) and an iron-sulfur protein (Fe-S). FMN, which is derived from vitamin B2, also called riboflavin, is one of several prosthetic groups or cofactors in the electron transport chain. A prosthetic group is a non-protein molecule necessary for the activity of a protein. Prosthetic groups are organic or inorganic molecules, not peptides bound to a protein that facilitates their function; Prosthetic groups include co-enzymes, which are the prosthetic groups of enzymes. The enzyme in complex I is NADH dehydrogenase and is composed of 44 separate chains of polypeptides. Complex I can pump four hydrogen ions through the matrix membrane into the intermembrane space, and this is how the hydrogen ion gradient is established and maintained between the two compartments separated by the inner mitochondrial membrane. Complex II directly receives FADH2, which does not pass through complex I. The compound that connects the first and second complexes to the third is ubiquinone (Q). The Q molecule is soluble lipid and moves freely through the hydrophobic nucleus of the membrane. Once reduced, (QH2), ubiquinone delivers its electrons to the next complex in the electrons. Q receives nadh-derived electrons from complex I, and electrons derived from This enzyme and FADH2 form a small complex that supplies electrons directly into the electron transport chain, bypassing the first complex. Since these electrons byturn and therefore do not energize the proton pump in the first complex, fewer ATP molecules are made from fadh2 electrons. The number of ATP molecules finally obtained is directly proportional to the number of protons pumped through the internal mitochondrial membrane. The third complex consists of cytochrome b, another Fe-S protein, rieske center (center 2Fe-2S) and cytochromatic proteins c; this complex is also called cytochrome oxydoreductase. Cytochromatic proteins have a prosthetic heme group. The heme molecule is similar to the heme in hemoglobin, but carries electrons, not oxygen. As a result, the iron ion in its nucleus is reduced and oxidized as it passes through electrons, floating between different oxidation states: Fe++ (reduced) and Fe+++ (oxidized). Heme molecules in cytochromes have slightly different characteristics due to the effects of the different proteins that bind them, giving slightly different characteristics to each complex. Complex III pumpprotons through the membrane and passes its electrons to cytochrome c for transport to the fourth complex of proteins and enzymes (cytochrome c is the electron acceptor of Q; however, while Q carries electron pairs, cytochrome c can accept only one at a time). The fourth complex is composed of cytochromatic proteins c, a and a3. This complex contains two heme groups (one in each of the two cytochromes, a, and a3) and three copper ions (one pair of CuA and one CuB in cytochrome a3). Cytochromes hold an oxygen molecule very tightly between the iron and copper ions until oxygen is completely reduced. The reduced oxygen then captures two hydrogen ions from the surrounding medium to make water (H2O). The removal of hydrogen ions from the system contributes to the ion gradient used in the chemosmosis process. In chemiosmosis, the free energy of the series of redox reactions described only is used to pump hydrogen ions (protons) through the membrane. The unequal distribution of H+ ions through the membrane establishes concentration and electrical gradients (thus an electrochemical gradient), due to the positive charge of hydrogen ions and their aggregation on one side of the membrane. If the membrane were open to diffusion by hydrogen ions, the ions would tend to spread back into the matrix, driven by their electrochemical gradient. Remember that many ions cannot diffuse through the nonpolar regions of phospholipid membranes without the aid of ion channels. Similarly, hydrogen ions in the matrix space can only pass through the internal mitochondrial membrane through a protein of atp synthase (Figure 7.12). This complex protein acts like a tiny tiny transformed by the force of hydrogen ions spreading through it, down its electrochemical gradient. The transformation of parts of this molecular machine facilitates the addition of a phosphate to the ADP, forming ATP, using the potential energy of the hydrogen ion gradient. Figure 7.12 ATP synthase is a complex molecular machine that uses a proton gradient (H+) to form ATP from ADP and inorganic phosphate (Pi). (Credit: modification of klaus hoffmeier's work) Dinitrophenol (DNP) is a decoupler that causes the inner mitochondrial membrane leak protons (H+). It was used until 1938 as a weight loss drug. Why do you think it can be an effective drug for weight loss? DNP dissipates the proton gradient in the matrix, preventing ATP production. The body then increases its metabolic rate, leading to weight loss. DNP decreases the proton gradient in the internal mitochondrial space, leading to rapid consumption of acetyl-CoA, which causes weight loss. DNP blocks proton movement through ATP synthase, interrupting ATP production. Stored energy dissipates like heat, causing weight loss. DNP decouple atp production by increasing the proton gradient in the matrix. Stored energy dissipates like heat, causing weight loss. Chemiosmosis (Figure 7.13) is used to generate 90% of the ATP done during aerobic glucose catabolism; it is also the method used in light photosynthesis reactions to harness the energy of sunlight in the photophosphorylation process. Remember that atp production using the chemosmosis process in mitochondria is called oxidative phosphorylation. The general result of these reactions is the production of ATP from the energy of electrons removed from hydrogen atoms. These atoms were originally part of a glucose molecule. At the end of the pathway, electrons are used to reduce an oxygen molecule to oxygen ions. The extra electrons in oxygen attract hydrogen ions (protons) from the surrounding medium, and water is formed. Figure 7.13 In oxidative phosphorylation, the pH gradient formed by the electron transport chain is used by ATP synthase to form ATP. Cyanide inhibits cytochrome c oxidase, a component of the electron transport chain. If cyanide poisoning occurs, would you expect the pH of the intermembrane space to increase or decrease? What effect would cyanide have on ATP synthesis? The proton concentration of the intermembrane space would decrease, interrupting the production of ATP. The proton concentration of the intermembrane space would increase, leading to the formation of ATP. The concentration of hydrogen ions from the intermembrane space would decrease, causing a high production of ATP. The proton concentration of the intermembrane space would increase, causing the production of ATP in large quantities. The number of ATP molecules generated from glucose catabolism varies. For example, the number of ions that electron transport chain complexes can pump through the membrane varies between species. Another source of variance comes from the electron shuttle through the membranes of mitochondria. (Nadh generated from glycoglycais cannot easily enter mitochondria.) Thus, electrons are captured inside mitochondria by NAD+ or FAD+. As you learned earlier, these FAD+ molecules can carry fewer ions; consequently, fewer ATP molecules are generated when FAD+ acts as a carrier. Nad+ is used as the electron transporter in the liver and FAD+ acts in the brain. Another factor that affects the yield of ATP molecules generated from glucose is the fact that intermediate compounds in these pathways are used for other purposes. Glucose catabolism connects with the pathways that build or break all other biochemical compounds in cells, and the result is a little more confusing than the ideal situations described so far. For example, sugars other than glucose are fed on the glilytic pathway for energy extraction. In addition, five-carbon sugars that form nucleic acids are made of intermediates in glycolysis. Certain non-essential amino acids can be made from intermediates of both glycolysis and the citric acid cycle. Lipids, such as cholesterol and triglycerides, are also made from intermediates in these pathways, and both amino acids and triglycerides are broken down to energy through these pathways. In general, in living systems, these glucose catabolism pathways extract about 34% of the energy contained in glucose. This activity is an application of Objective Learning Practices 2.4 and Scientific Practices 1.4 and 3.1 and Learning Objective 2.5 and Scientific Practice 6.2 because students will have the opportunity to create a model of the electron transport chain, allowing students to study and discuss the components of the electron transport chain that allow organisms to capture , store and use free energy. An extended laboratory investigation into cellular respiration is available at the University Council®. This activity involves respirometry of vegetable seeds. It is available in the Investigative Laboratories of ® AP: A Survey-Based Approach, Research 6. Think About It questions are applications of Objective Learning Practices 2.4 and Scientific Practices 1.4 and 3.1 and Learning Objective 2.5 and Scientific Practice 6.2 because students are provided with situations that raise questions about cell breathing and are then asked to explain the effects of the factors that affect the process. Students are also connecting the structure of the mitochondria to their role in cellular respiration. If a cytochrome failed to perform a redox reaction, the electrons could not to the next cytochrome, and possibly not reach the proton pumps. Even if they reached the pumps, ETC could not discharge the electrons into oxygen, oxygen, any additional electrons travel down the ETC and also prevent any additional ATP production. The free energy in the electrons is transferred to proton pumps, allowing them to pump protons. Some are also lost as heat and the rest is transferred to oxygen at the end of the ETC. If only one electron reached oxygen, the water would not form at the end of the electron transport chain until another electron travels through the chain. In living cells, DNP acts as an agent that can directly transport protons through biological membranes. Therefore, it weakens the proton concentration gradient that causes protons to pass through ATP synthase. After DNP poisoning, the electron transport chain can no longer form a proton gradient, and ATP synthase can no longer do ATP. DNP is an effective dietary medicine because it decouples atp synthesis; in other words, after taking it, a person gets less energy from the food they eat. Interestingly, one of the worst side effects of this drug is hyperthermia, or overheating of the body. Because ATP cannot be formed, the energy of electron transport is lost as heat. After cyanide poisoning, the electron transport chain can no longer pump protons into the intermembrane space. The pH of the intermembrane space would increase, the pH gradient would decrease, and the ATP synthesis would stop. Stop.

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