Section 5.6: Photosynthesis and Cellular Respiration: A Comparison

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1. Chloroplasts are the sites of photosynthesis in eukaryotes. No, not all plant cells contain chloroplasts. Only green plant cells contain chloroplasts.

2. Mitochondria are the sites of the oxygen-requiring stages of aerobic cellular respiration in eukaryotes. Yes, virtually all plant and animal cells contain mitochondria.

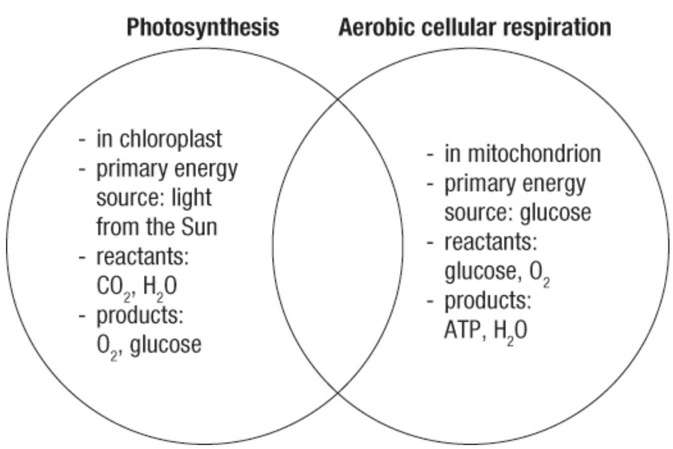
3. (a) The overall equation is misleading as it does not account for all of the many smaller reactions that must take place and the numerous enzymes, coenzymes, and intermediate chemicals involved in the process. It shows the conversions of glucose and water to carbon dioxide (and vice versa) as a simple, one-step process, when it is actually much more complicated than that. It also does not account for light energy, which is essential for photosynthesis.

(b) It is easy to understand the photosynthesis respiration equation in terms of heterotrophs because they undergo one side of the equation (left to right, cellular respiration) and rely on autotrophs for the other side of the equation (right to left, photosynthesis). Plants do not only photosynthesize. They are also constantly undergoing cellular respiration; therefore, they are active on both sides of the equation.

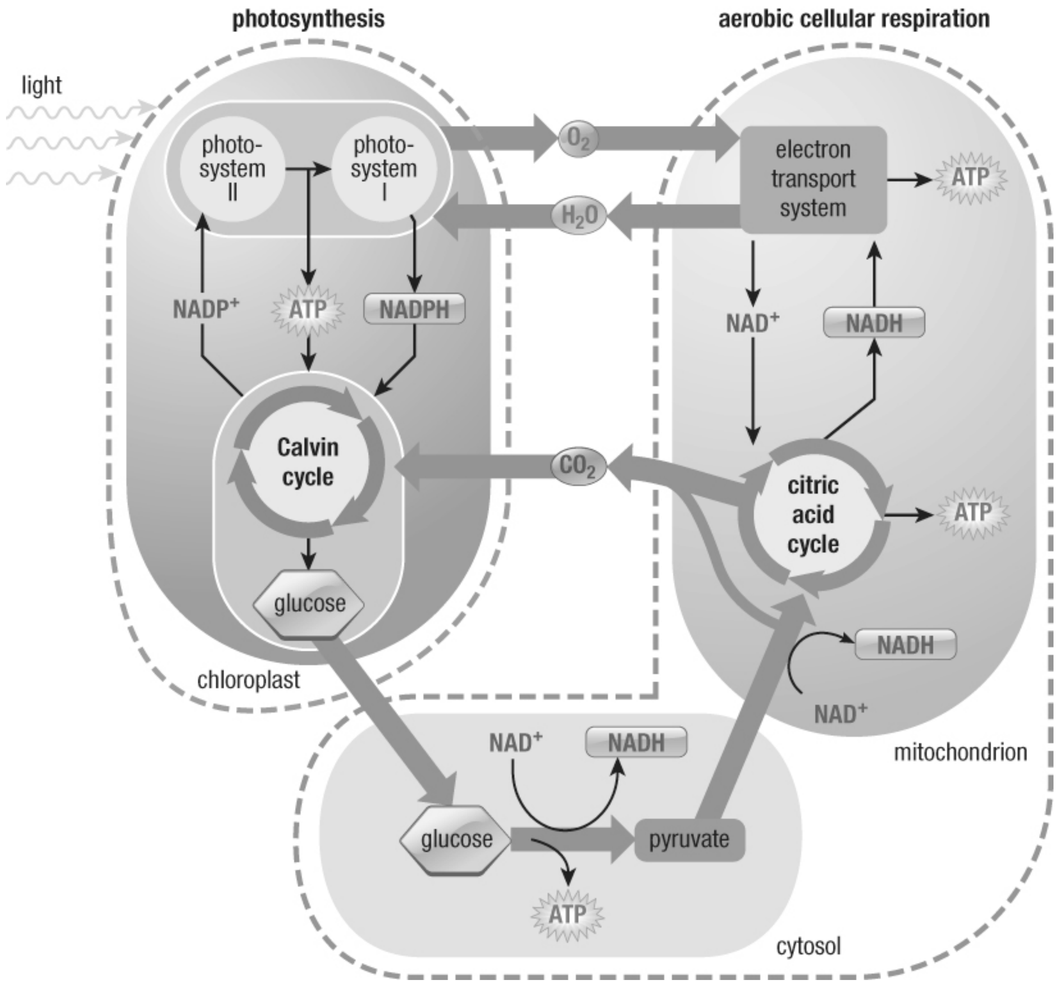
(c) The O_2 in the photosynthesis and respiration equation is not created by CO_2. The CO_2 actually gets converted to sugars in photosynthesis and the O_2 gets converted to water in cellular respiration.

4. Chloroplasts and mitochondria are membrane-bound organelles. Mitochondria have an outer membrane and a highly folded inner membrane. Chloroplasts have an outer membrane, an inner membrane, and a third membrane system of highly folded and stacked thylakoids. Both chloroplasts and mitochondria have electron transport chains and synthesize ATP. They also have complementary carbon fixing and carbon-releasing cycles within them. The source of energy used by chloroplasts is light. The source of energy used by mitochondria is pyruvate. All of photosynthesis takes place in the chloroplasts. Glycolysis is part of aerobic cellular respiration, but it does not take place in mitochondria.

5.



6. Only autotrophs can carry out photosynthesis, but both autotrophs and aerobic heterotrophic organisms can carry out cellular respiration. Heterotrophs are consumers; therefore, they must rely on autotrophs for the synthesis of the organic molecules they use as energy and as building materials for growth.
7. The electron transport chains in both photosynthesis and cellular respiration transport excited electrons "down" an energy gradient. The major difference between the two processes is that photosynthetic electron transport requires an input of light energy to raise the electrons to the excited states.
8. The source of electrons in photosynthesis is water, which is split as light energy is absorbed and transferred. The sources of electrons in aerobic cellular respiration are NADH and $FADH_2$, which are created during a series of reactions that extract energy from sugars such as glucose.
9. Both NADPH and NADH function as electron carriers. NADPH is the product of the light-dependent reactions of photosynthesis, and is used to carry high-energy electrons and hydrogen to the Calvin cycle to fix carbon. NADH is used in aerobic cellular respiration as a carrier of high-energy electrons and hydrogen from glycolysis, pyruvate oxidation, and the citric acid cycle to the electron transport system.
10. As seen in Figure 1 on the following page, CO_2 is initially fixed in the Calvin cycle of photosynthesis. Through a series of reactions, CO_2 is integrated into a glucose molecule. The carbon-bearing glucose then enters the aerobic cellular respiration oxidation pathway. Cellular respiration begins with glycolysis in the cytosol, where a series of reactions break glucose down into pyruvate molecules. The pyruvate carries the carbon atom into the mitochondrion where it is further oxidized and released as CO_2 during pyruvate oxidation. The acetyl group produced during pyruvate oxidation enters the citric acid cycle, where it undergoes further reactions that release CO_2. As the cycle turns, eventually all the carbon atoms that were present in the original pyruvate molecule are oxidized to CO_2.



11. The function of chloroplast DNA is to carry the code for many of the proteins needed for chloroplast function, such as components involved in photosynthesis. Similarly, mitochondrial DNA encodes proteins needed for mitochondrial function, such as enzymes involved in oxidative phosphorylation. The DNA in our own mitochondria is maternally inherited (inherited from our mothers).

