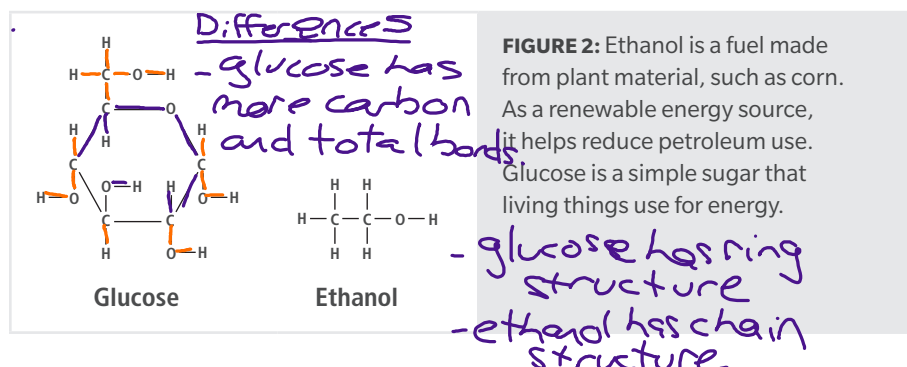


Matter and Energy in Cellular Respiration

Fuel is any material that reacts to release energy to be used for work. Not all fuels are alike. They have many different chemical structures.

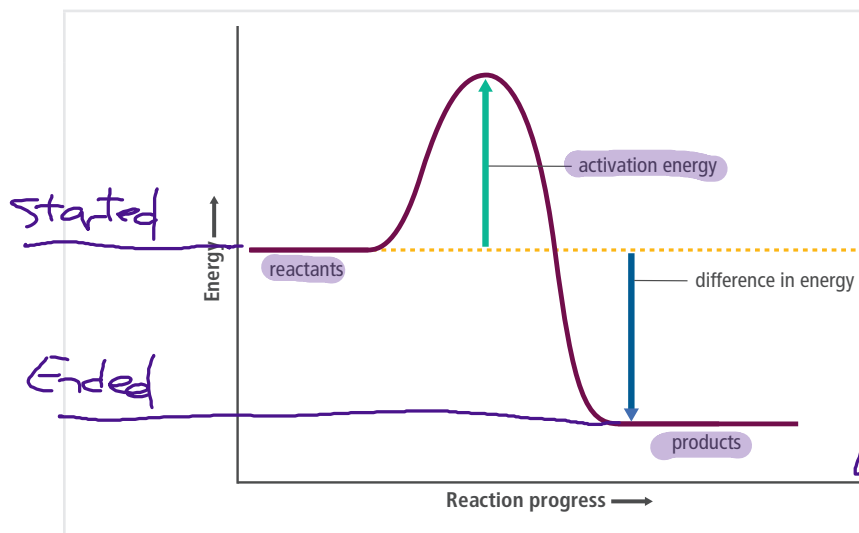


Analyze How are glucose and ethanol similar in structure and function? How do they differ?

Energy in Living Systems

Whether food for organisms or fuel for cars, almost all the energy on Earth has its origins in the sun. In the process of photosynthesis, plants transform light energy from the sun into chemical energy in the form of glucose. When an organism eats a plant, any energy the plant has not used can be used by the consumer.

Ancient plants and animals that died decomposed and were buried under soil, rock, and sometimes sea water. These organisms decomposed into organic materials that contain unused stored energy. Over millions of years, heat and pressure transformed these remains into the fossil fuels we use today. Chemical bonds must be broken for the stored energy to be released. In cars, a combustion reaction provides the energy needed to break these bonds and release energy. In cells, a similar process called **cellular respiration** releases chemical energy from sugars and other carbon-based molecules to make ATP when oxygen is present.



Exothermic Reaction

FIGURE 3: Activation energy is the energy needed to start a chemical reaction. An exothermic reaction releases more energy than it absorbs. Cellular respiration is an exothermic reaction.

claim: Cellular respiration is an exothermic reaction.

Evidence: The energy of the product is less than the energy of the reactant.



Gather Evidence Explain why cellular respiration is an exothermic reaction. Cite evidence from the graph shown in Figure 3 to support your explanation.



Cellular Respiration and Exercise

Burning fuel through either combustion or cellular respiration requires oxygen. In each process, bonds break and new bonds form. In this lab, you will use an indicator called bromothymol blue to gather evidence to support a claim about the inputs and outputs of cellular respiration. Bromothymol blue changes color in the presence of an acid.



Predict What evidence could there be to support the claim that during cellular respiration, chemical bonds are broken and new bonds are formed?

SAFETY

Do not consume any of the materials used in this lab. Be careful not to breathe in through the straw.

MATERIALS

- bromothymol blue solution
- cups or beakers (2)
- straw
- timer



PROCEDURE

1. Place the amount of bromothymol blue solution specified by your teacher in a cup or beaker.
2. Get the timer ready. Slowly blow through the straw into the bromothymol blue solution, and record how long it takes for the solution to change from blue to yellow. Be sure not to inhale when the straw is in the solution.
3. Place the amount of bromothymol blue solution specified by your teacher in a second cup or beaker.
4. Run in place for approximately one minute.
5. Get the timer ready again. Slowly blow through the straw into the bromothymol blue solution, and record how long it takes for the solution to turn yellow.

ANALYZE

The water turned acidic when you blew into it because carbon dioxide in your breath reacted with water to form carbonic acid.

1. How do your findings support the claim that bonds were broken and new bonds were formed to produce the gas you breathed out?
2. When you exercised, what was different about the time it took the solution to change color? Explain why this happened.

FIGURE 4:

Bromothymol blue is an indicator that changes color in the presence of an acid.



The Process of Cellular Respiration

During cellular respiration, the breakdown of glucose and other carbon-based molecules releases energy stored in their chemical bonds. The stored energy is transferred to ATP, which we can think of as the cell's "energy currency." Energy in the form of heat is also released in the process. The release of heat accounts for why the body temperatures of mammals range from 36 to 39°C (97–103°F).

Cellular respiration is an **aerobic process**, which means that it requires oxygen to take place. Some organisms can produce small amounts of ATP through **anaerobic processes**, or processes that do not require oxygen. However, the presence of oxygen allows cellular respiration to produce far more ATP from each glucose molecule. The inputs and outputs of cellular respiration are shown in Figure 5.

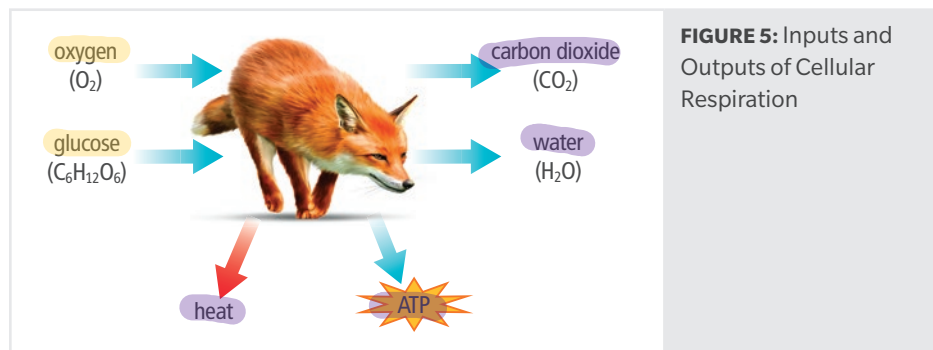


FIGURE 5: Inputs and Outputs of Cellular Respiration

Explain What is the role of the organism in this model of cellular respiration? Explain your answer.

Energy and Matter The balanced chemical equation for cellular respiration is:



1. How does this equation represent the law of conservation of matter—that matter cannot be created or destroyed?
2. How does this equation represent the law of conservation of energy—that energy cannot be created or destroyed? Consider the role of photosynthesis in your answer.

Mitochondria

Cellular respiration takes place inside an organelle called the **mitochondrion** (plural *mitochondria*), shown in Figure 6. Mitochondria release the chemical energy required to make ATP. Both plant and animal cells contain mitochondria, because both plants and animals carry out cellular respiration.

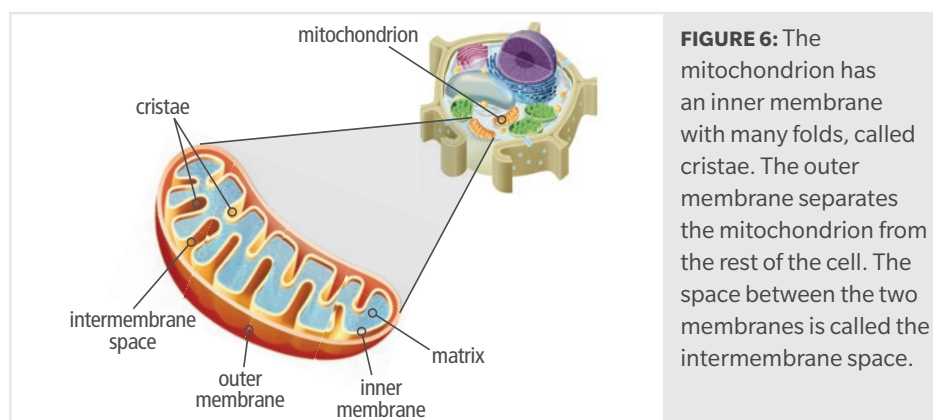


FIGURE 6: The mitochondrion has an inner membrane with many folds, called cristae. The outer membrane separates the mitochondrion from the rest of the cell. The space between the two membranes is called the intermembrane space.

Collaborate With a partner, cite evidence that supports the claim that mitochondria are the "powerhouses of the cell."



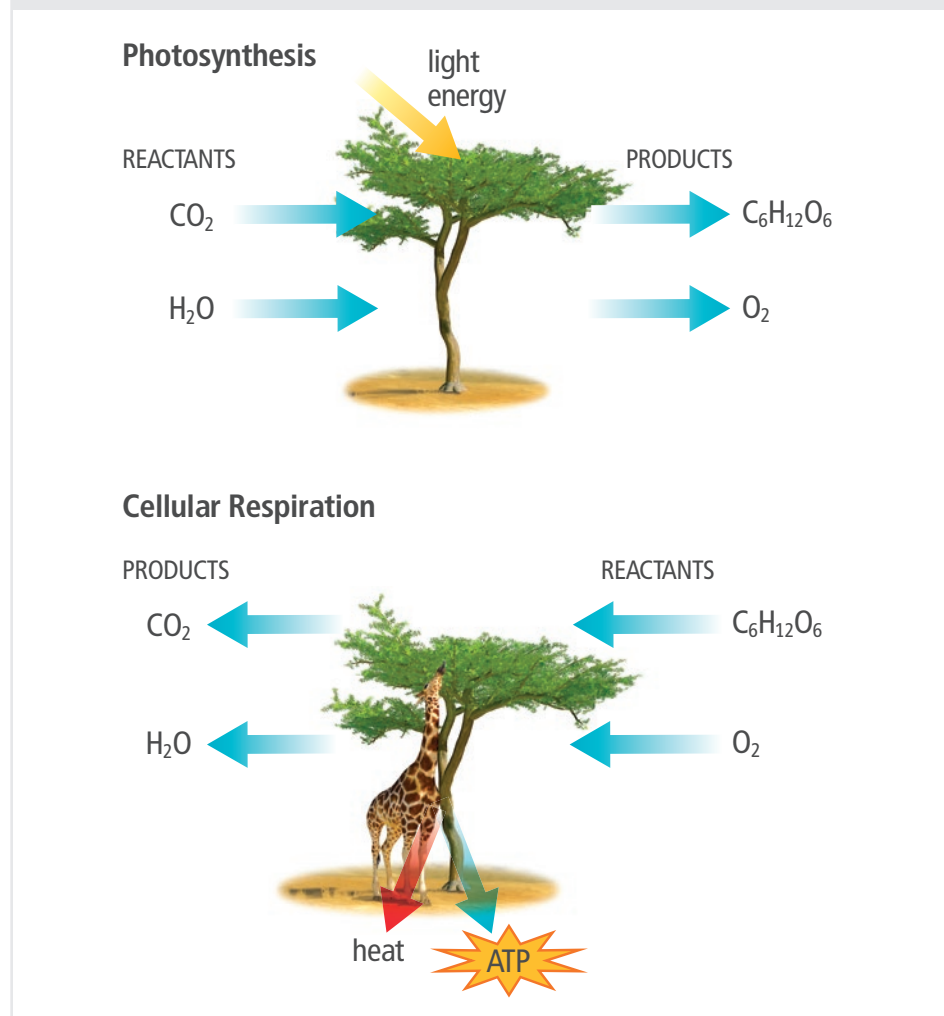
Investigating Photosynthesis and Cellular Respiration Design an experiment to determine which organisms (pond snails or *Elodea*) produce carbon dioxide and which use carbon dioxide.

Analyze What is the relationship between the inputs and outputs of photosynthesis and cellular respiration?

Cellular Respiration and Photosynthesis

Almost all energy for living things comes from photosynthesis, either directly or indirectly. Producers absorb light energy from the sun and transform it using photosynthesis to a usable form of energy, or food. This energy is then passed from producers to consumers. Although only producers carry out photosynthesis, both producers and consumers carry out cellular respiration. Photosynthesis stores energy from sunlight as chemical energy. In contrast, cellular respiration releases stored energy as ATP and heat.

FIGURE 7: A Comparison of Photosynthesis and Cellular Respiration



Model Sort the following terms into those that occur during photosynthesis and those that occur during cellular respiration. Then place the terms in the correct order.

- absorption of sunlight
- ATP production
- production of sugars
- breakdown of sugars

1 photosynthesis
4 cell respiration
2 photosynthesis
3 cell respiration