Cellular Respiration

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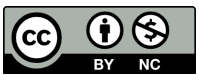

CHAPTER 1

Cellular Respiration

Lesson Objectives

- Write and explain the chemical formula for cellular respiration.
- Explain the two states of cellular respiration.
- Compare photosynthesis with cellular respiration.

Check Your Understanding

- Where does the energy captured at the beginning of photosynthesis originate from?
- What is the form of chemical energy produced by photosynthesis?
- What occurs in oxidation and reduction reactions?

Vocabulary

- aerobic respiration
- alcoholic fermentation
- anaerobic respiration
- ATP
- cellular respiration
- fermentation
- lactic acid fermentation

What is Cellular Respiration?

How does the food you eat provide energy? When you need a quick boost of energy, you might reach for an apple or a candy bar. But cells do not "eat" apples or candy bars, these foods need to be broken down so that cells can use them. Through the process of **cellular respiration,** the energy in food is changed into energy that can be used by the body's cells. In other words, glucose and oxygen are converted into ATP, carbon dioxide, and water. **ATP**, or adenosine triphosphate, is chemical energy the cell can use. It is the molecule that provides energy for your cells to perform work, such as moving your muscles as you walk down the street.

The Process of Cellular Respiration

What happens inside of the cell? Glucose is broken down in the cytoplasm of the cells and then transported to the mitochondria, the organelles known as the energy "powerhouses" of the cells (**Figure** 1.1). Inside the mitochondria, the "broken-down" glucose is broken down again to release ATP. Oxygen is needed to help the process of turning

glucose into ATP. The initial step releases just two molecules of ATP for each glucose. The later steps release much more ATP.

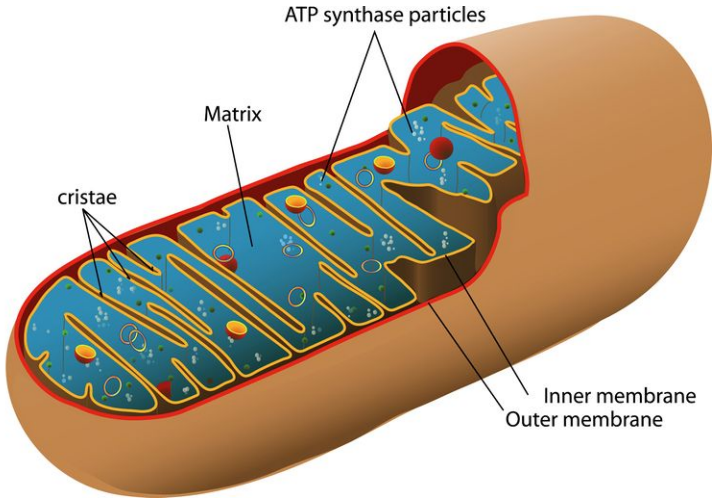

FIGURE 1.1
Most of the reactions of cellular respiration are carried out in the mitochondria.

The Reactants

What goes into the cell? Oxygen and glucose are both reactants in the process of cellular respiration. Oxygen enters the body when an organism breathes. Glucose enters the body when an organism eats.

The Products

What does the cell produce? The main product of cellular respiration is ATP. Waste products include carbon dioxide and water. Carbon dioxide is transported from your mitochondria out of your cell, to your red blood cells, and back to your lungs to be exhaled.

When one molecule of glucose is broken down, it can be converted to a net total of 36 or 38 molecules of ATP. This only occurs in the presence of oxygen.

The Chemical Reaction

The overall chemical reaction for cellular respiration is 1 molecule of glucose ($C_6H_{12}O_6$) and 6 molecules of oxygen (O_2) yields 6 molecules of carbon dioxide (CO_2) and 6 molecules of water (H_20). Using chemical symbols the equation is represented as follows:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Connecting Cellular Respiration and Photosynthesis

Notice that the equation for cellular respiration is the direct opposite of photosynthesis (**Figure** 1.2). While water was broken down to form oxygen during photosynthesis, in cellular respiration oxygen is combined with hydrogen to form water. While photosynthesis requires carbon dioxide and releases oxygen, cellular respiration requires oxygen and releases carbon dioxide. This exchange of carbon dioxide and oxygen in all the organisms that use

photosynthesis or cellular respiration worldwide helps to keep atmospheric oxygen and carbon dioxide at stable levels.

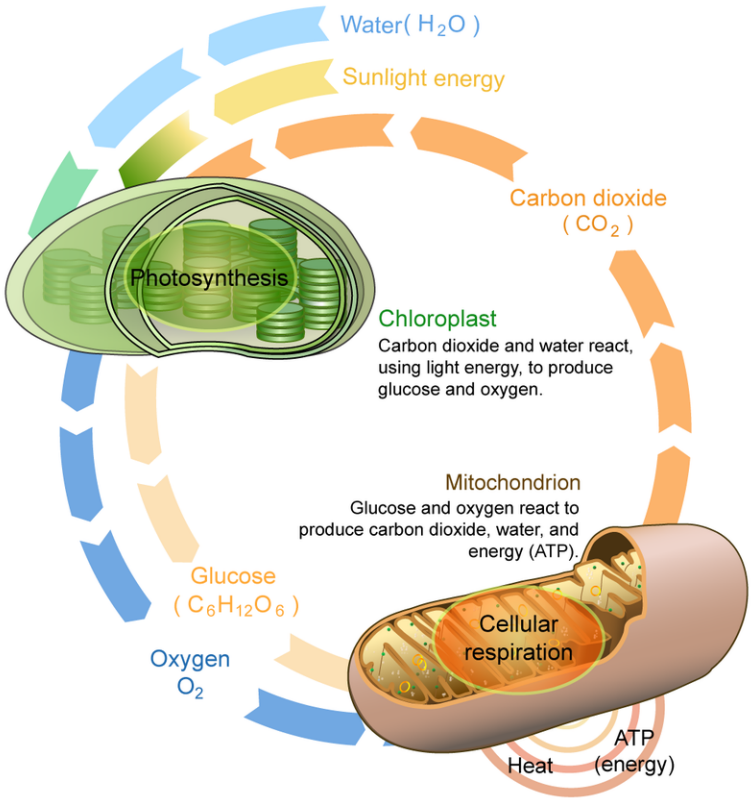

FIGURE 1.2

Cellular respiration and photosynthesis are direct opposite reactions. Some of the ATP made in the mitochondria is used as energy for work, and some is lost to the environment as heat. Can you explain what is depicted in this diagram?

Fermentation

Sometimes cellular respiration is **anaerobic**, occurring in the absence of oxygen. In this process, called **fermentation**, no additional ATP is produced, so the organism only obtains the two ATP molecules per glucose molecule from the initial step of this process (compare that to 36-38 ATP produced with oxygen!).

Yeasts (single-celled eukaryotic organisms) perform **alcoholic fermentation** in the absence of oxygen, making ethyl alcohol (drinking alcohol) and carbon dioxide. This process is used to make common food and drinks. For example, alcoholic fermentation is used to bake bread. The carbon dioxide bubbles allow the bread to rise, and the alcohol evaporates. In wine making, the sugars of grapes are fermented to produce the wine.

Animals and some bacteria and fungi carry out **lactic acid fermentation.** Lactic acid is a waste product of this process. Our muscles perform lactic acid fermentation during strenuous exercise, when oxygen cannot be delivered to the muscles quickly enough. The buildup of lactic acid is what makes your muscles sore after exercise.

Bacteria that produce lactic acid are used to make cheese and yogurt (**Figure** 1.3). Tooth decay is also increased by lactic acid from the bacteria that use the sugars in your mouth for energy.

FIGURE 1.3

Products of fermentation include cheese (lactic acid fermentation) and wine (alcoholic fermentation).

Lesson Summary

- Cellular respiration is the breakdown of glucose to release energy in the form of ATP.
- If oxygen is not available, the process of fermentation can break down glucose without the presence of oxygen.

A summary of cellular respiration can be viewed at http://www.youtube.com/watch?v=wqqYIgY40OE (8:50).

MEDIA

Click image to the left for more content.

Review Questions

Recall

1. What is the purpose of cellular respiration?
2. Where is glucose broken down to form ATP?

Apply Concepts

3. What are the products of alcoholic fermentation?
4. Write the chemical reaction for the overall process of cellular respiration.
5. What produces more ATP, aerobic or anaerobic cellular respiration? What is the purpose of fermentation?

Critical Thinking

6. Why do your muscles get sore after vigorous exercise?
7. Why is the cellular respiration equation the opposite of the photosynthesis equation?

Supplemental Links

- http://biology.clc.uc.edu/Courses/bio104/cellresp.htm
- http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookGlyc.html
- http://biology.clc.uc.edu/Courses/bio104/cellresp.htm
- http://www.science.smith.edu/departments/Biology/Bio231/glycolysis.html

Points to Consider

- What do you think could happen if your cells divide uncontrollably?
- When new life is formed, do you think it receives all the DNA of the mother and the father?
- Why do you think you might need new cells throughout your life?

References

1. Mariana Ruiz Villarreal (User:LadyofHats/Wikimedia Commons). http://commons.wikimedia.org/wiki/File:Animal_mitochondrion_diagram_en.svg . Public Domain
2. Mariana Ruiz Villarreal (LadyofHats) for the CK-12 Foundation. CK-12 Foundation . CC BY-NC 3.0
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