Unit 2

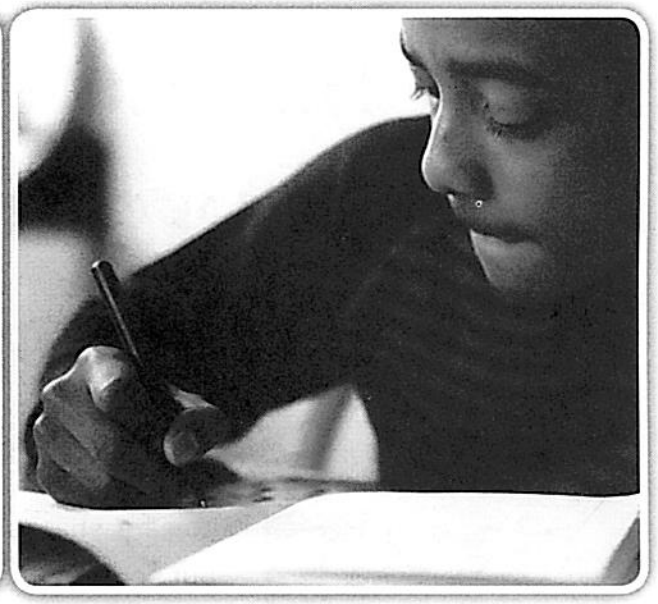
Matter and Energy in Organisms and Ecosystems

You are what you eat. This is true of all living things. But how does energy get into food? For that matter, what is food, really? How does the stuff in food become the stuff that makes up your body, or the body of a squid, or the body of an apple tree?

In this unit, you will explore the processes that store energy in food. You will also examine the process that releases energy from food. You will discover how the stuff that makes up your body may have once been part of a squid or an apple tree. You will even discover how a whale shark gets its energy.

Lesson 4

Photosynthesis



Living things need energy.

It takes energy to play a sport or learn new things. When you get tired, how do you boost your energy so that you can continue playing or studying?

Share your ideas with a partner. Sort the ideas into two or three different categories. Record your categories in the table below. Then give two examples for each category.

Category	Examples
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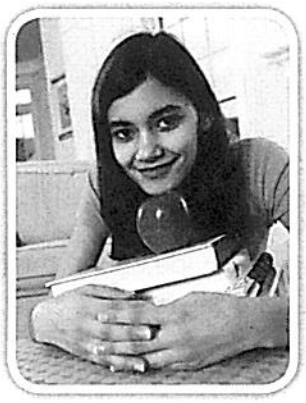
One way to boost energy is to eat something. Like other animals, humans need food for energy. All living things break down food to get energy. This energy powers life processes and enables living things to grow and thrive.



What kinds of foods do animals eat? How can these different kinds of foods be categorized?

The apple and the carrot in the photographs are food. They are also living things. Like all living things, plants break down food to get energy. But plants do not eat food.

How do plants get the food they need? Where does this food come from?

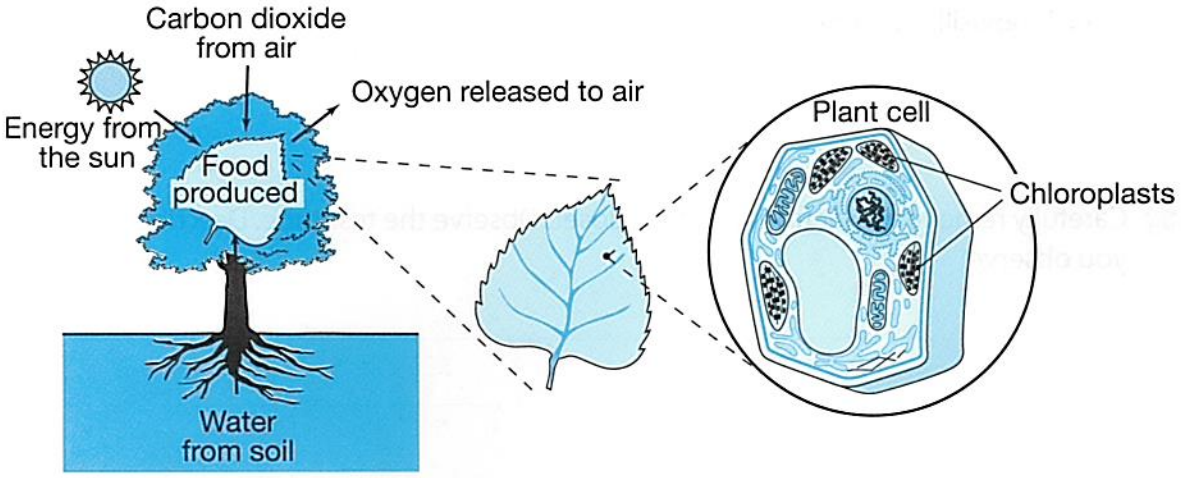
Look Ahead

In this lesson, you will solve the mystery of how plants get their food. You will discover how this process produces waste products. As it turns out, these waste products are needed for other living things—including humans—to survive.

Understand

You observed that the test tube placed in the dark closet was still filled with water. The test tube in the sunny window had less water. The water had been replaced by gas. How did the gas get into the test tube? The answer lies in the way plants get the food they need.

Animals get their food by eating it. Plants are different. Specialized cells in plants (and some other organisms) make their own food. To make food, plant cells use light energy to combine carbon dioxide and water. This produces food and oxygen. This food-making process is called photosynthesis.



Look carefully at the diagram. What three things do plants need to carry out photosynthesis? Where do these come from?

Plants get the materials they need for photosynthesis from their environment. They absorb carbon dioxide from the air. Air enters a plant through tiny holes in the leaves. Plants absorb water from the soil through their roots. Specialized cells in the plant's stem transport the water to the leaves.

Photosynthesis takes place in chloroplasts. Recall from Lesson 1 that chloroplasts are structures found in plant cells. Chloroplasts contain a green pigment, or colored chemical, called chlorophyll. Chlorophyll traps the energy in sunlight. This energy is used to change carbon dioxide and water into glucose, food for the plant.

Look at the diagram of photosynthesis again. What two substances are produced by photosynthesis?

The food produced by photosynthesis is a basic chemical building block called glucose. Glucose is a type of sugar. However, it is not the table sugar that you buy at a supermarket. It is simpler than that.

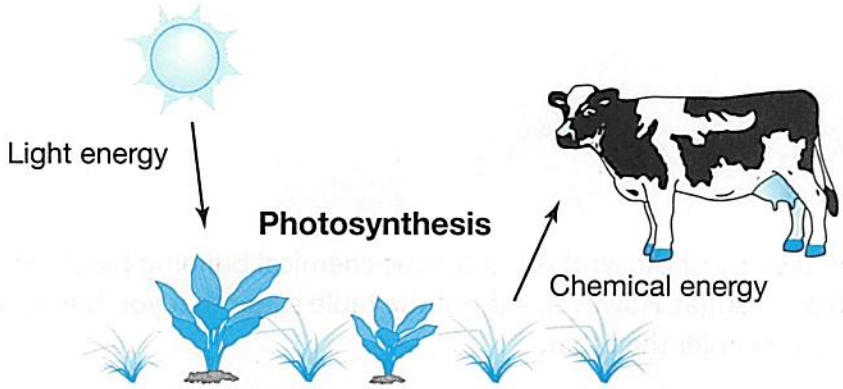
Glucose is the starting point for many chemical reactions. Chemical reactions are processes in which chemicals are turned into other chemicals. For example, a chemical reaction can rearrange glucose into a different kind of sugar. This other sugar can react with glucose to form the more complex chemical known as table sugar. Table sugar may react with other chemicals to form still more complex chemicals. The bodies of living things are made up of many complex chemicals. All of these can be traced back to glucose.

A plant has many uses for glucose. However, it does not need most of the oxygen produced during photosynthesis. It releases oxygen gas as a waste product. In this way, plants provide the oxygen that most life on Earth needs to survive.

Some chemical reactions use energy. Others release energy.

Does photosynthesis use energy or release energy? How do you know this?

Energy flows through the environment. It passes from nonliving parts of the environment into living things. It flows from one kind of living thing to another.



In the diagram, how does energy flow from the sun to the cow?

As energy flows through the environment, it can transform, or change from one form to another. There are many forms of energy, including heat energy, light energy, sound energy, and chemical energy.

What transformation of energy takes place in photosynthesis?

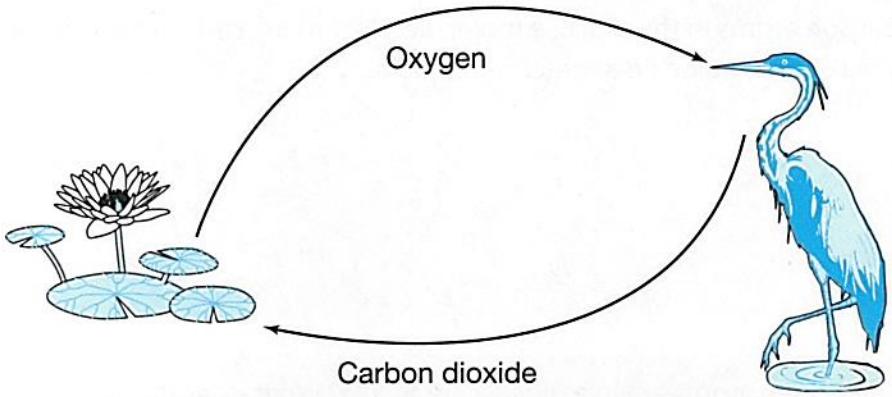
Why is this energy transformation important to living things?

Earlier in this lesson, you learned that glucose is a chemical building block. Glucose is also an energy storehouse. The light energy captured during photosynthesis is stored as chemical energy in glucose.

What might happen if glucose was broken back down into water and carbon dioxide?

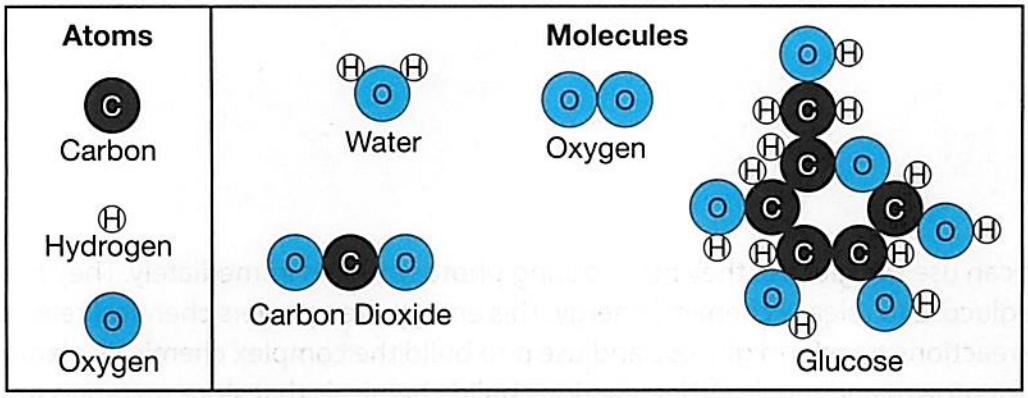
Plants can use the glucose they make during photosynthesis immediately. They break down glucose to release chemical energy. This energy then powers chemical reactions. Some reactions transform glucose and use it to build the complex chemicals plants need for growth and repair. Other reactions build chemicals that store materials and energy for later use.

When organisms break down glucose for energy, they produce carbon dioxide. Animals get rid of this waste product when they breathe out.



How do animals and plants depend on one another for materials they need?

A molecule is the smallest particle of a substance that is still that substance. A carbon dioxide molecule is the smallest particle that is still carbon dioxide. Molecules consist of tiny parts called atoms. A carbon dioxide molecule consists of one carbon atom and two oxygen atoms. The diagram shows models of the molecules involved in photosynthesis and the atoms that make up these molecules.



Looking at molecules and atoms can help you understand what happens in photosynthesis. It gives you the details about how the atoms in water and carbon dioxide rearrange to form oxygen and *one* molecule of glucose.

Count the carbon atoms in the glucose molecule. How many carbon dioxide molecules are used to make one molecule of glucose? Explain.

How many hydrogen atoms are in a glucose molecule? What does this tell you about how many water atoms are used in photosynthesis?

Look again at the diagram of molecules involved in photosynthesis. How many oxygen molecules are produced in the photosynthesis of one glucose molecule?

How do the waste products of photosynthesis relate to what you observed in the Explore activity?

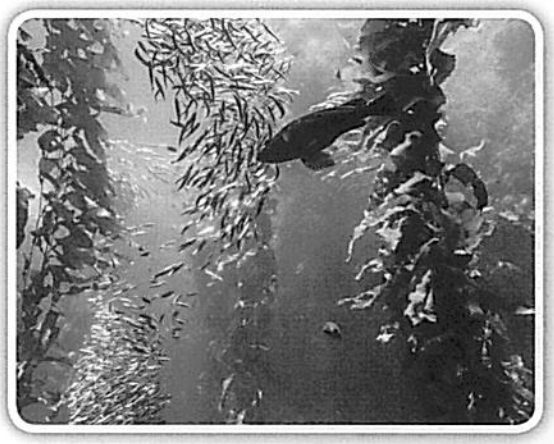
Animals cannot transform light energy into chemical energy. They also cannot make glucose, or any other organic molecule, from simple molecules like water and carbon dioxide. Organic molecules are the complex carbon-based chemicals in living things. Glucose is an organic molecule. All of the carbon-based molecules that make up the cells of living things are organic molecules.

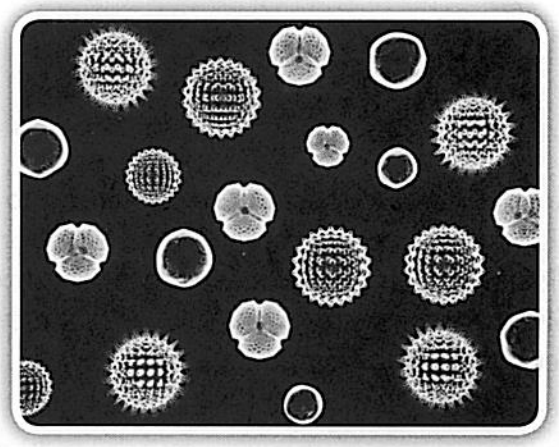
Where do animals get the organic molecules they need for growth and repair?

Suppose you eat an apple. How do your organ systems and cells process your food to give you organic molecules for growth or later use? How do they process food to give you energy?

Go Further

Plants are not the only living things that perform photosynthesis. Algae, such as the green slime you might find at the edges of a pond, is photosynthetic. Some kinds of algae, like the giant kelp in the photograph on the left, are enormous. Giant kelp can grow up to 80 meters tall.





Most of the photosynthesis in Earth's oceans is the work of tiny organisms, not giant ones. The photograph on the right shows some unicellular algae. These floating algae, or phytoplankton, are much smaller than shown here. They are actually microscopic. Phytoplankton are as essential to life in the ocean as plants are to life on land.

Use what you know about photosynthesis to explain how phytoplankton supports life in the oceans.

Phytoplankton are not the only microorganisms, or microscopic organisms, that perform photosynthesis. They are not even the ones that have had the biggest impact on life on Earth.

The first photosynthetic microorganisms appeared about 2.7 billion years ago. At first, their waste product, oxygen, was absorbed by chemical reactions with rocks. Almost no oxygen got into the air. However, about 2.3 billion years ago, the rocks could not absorb any more oxygen.

What happened to Earth's air about 2.3 billion years ago? How is this similar to what happened in the Explore activity at the beginning of this lesson?

The change in Earth's air had a huge impact on Earth's living things. Oxygen reacts with other chemicals easily. This made it poisonous to most of the organisms then living. Increased oxygen levels in Earth's atmosphere killed off these organisms.

Organisms that could live with oxygen survived and took the place of those that had died off. The new conditions also paved the way for new types of organisms. These new organisms had a new way of obtaining energy from food. The most efficient way to extract energy from glucose is to combine it with oxygen gas. This produces carbon dioxide and water. The process can be thought of as the opposite of photosynthesis.

How did photosynthesis make this new energy-extracting process possible?

Do you think animals could have developed if the atmosphere had not changed? Explain.

Check Your Understanding

1 What materials are needed for photosynthesis? Select all that apply.

A ☐ carbon dioxide

B ☐ glucose

C ☐ oxygen

D ☐ water

E ☐ sunlight

2 Complete the formula for photosynthesis below using these terms:

glucose, oxygen, carbon dioxide, water

Sunlight + _____ + _____ → _____ + _____

3 Which organisms can make their own food?

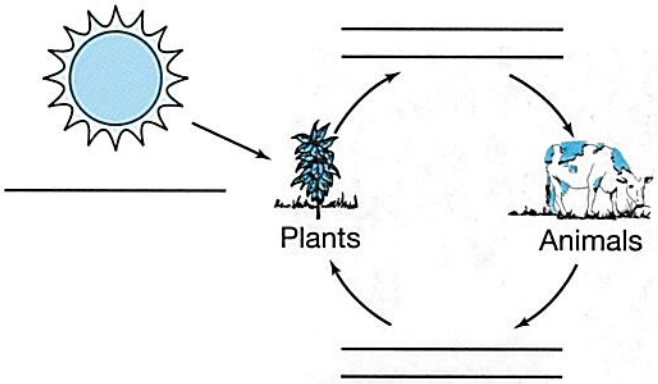
A ☐ plants only

B ☐ animals only

C ☐ plants and animals

D ☐ plants, algae, and many microorganisms

4 Use the words in the word bank to complete the diagram.



carbon dioxide
chemical energy
oxygen
light energy

5 Can plants make their food from sunlight? Use what you have learned in this lesson to defend your reasoning.

6 Explain how the sun helps people get the energy they need to study, play, and grow. Use examples to illustrate your understanding.