1–3 Studying Life

Guide for Reading

Key Concepts
- What are some characteristics of living things?
- How can life be studied at different levels?

Vocabulary
biology
cell
sexual reproduction
asexual reproduction
metabolism
stimulus
homeostasis
evolution

Reading Strategy: Summarizing As you read, make a list of the properties of living things. Write one sentence describing each property.

Beneath the sparkling waves near a South Pacific island, divers carry cameras and underwater notepads as they crisscross a coral reef. Outside an Antarctic research station, a lone figure searches the ice around her for signs of life. In a high-security facility in Atlanta, a man dressed like an astronaut passes through a double airlock into a sterile laboratory. Sweltering in the heat and humidity of sub-Saharan Africa, volunteers collect blood samples from women and children with AIDS. What do these people have in common? They are all biologists.

The word *biology* means the study of life. (The Greek word *bios* means "life," and *-logy* means "study of.") **Biology** is the science that seeks to understand the living world. A biologist is someone who uses scientific methods to study living things. The work of biologists can be quite varied, because organisms are complex and vary so greatly.

Characteristics of Living Things

Are the firefly and the fire in **Figure 1–14** alive? They are both giving off energy. Describing what makes something alive is not easy. No single characteristic is enough to describe a living thing. Also, some nonliving things share one or more traits with living things. Mechanical toys, automobiles, and clouds move around, for example, whereas mushrooms and trees live their lives in one spot. Other things, such as viruses, exist at the border between organisms and nonliving things. (You'll read more about viruses in Chapter 19.)

Despite these difficulties, it is possible to describe what most living things have in common. **Living things share the following characteristics:**

- **Living things are made up of units called cells.**
- **Living things reproduce.**
- **Living things are based on a universal genetic code.**
- **Living things grow and develop.**
- **Living things obtain and use materials and energy.**
- **Living things respond to their environment.**
- **Living things maintain a stable internal environment.**
- **Taken as a group, living things change over time.**

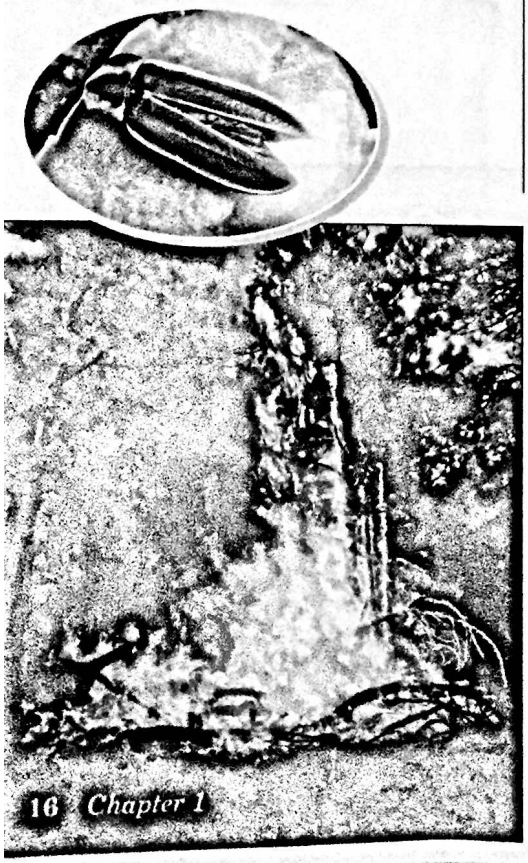
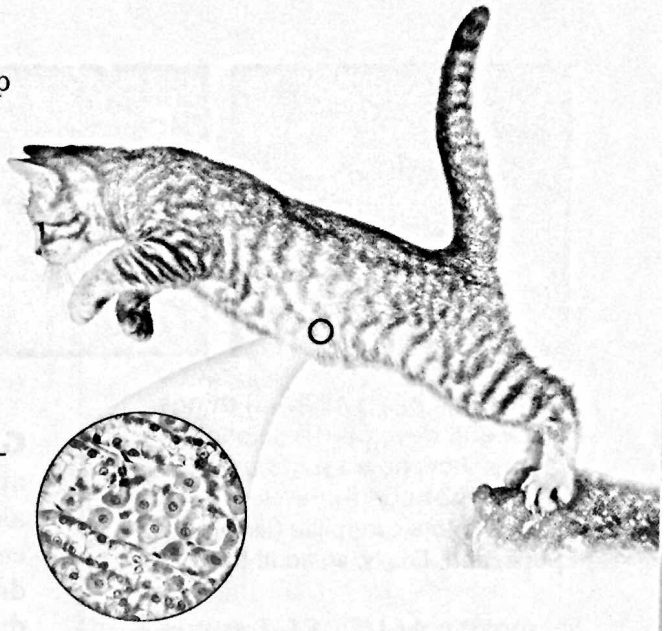


Figure 1–14 A Colorado firefly beetle (top) has all of the characteristics of living things. Even though fire (bottom) uses materials and can grow as living things do, fire is not alive because it does not have other characteristics of living things. **Applying Concepts** *What characteristics of living things are missing from a fire?*

Made Up of Cells Living things, or organisms, are made up of small, self-contained units called cells. A **cell** is a collection of living matter enclosed by a barrier that separates the cell from its surroundings. Cells are the smallest units of an organism that can be considered alive. Cells can grow, respond to their surroundings, and reproduce. Despite their small size, cells are complex and highly organized.

Many living things consist of only a single cell and are therefore called unicellular organisms. (The Latin prefix *uni-* means "one," so *unicellular* means "single-celled.") Many of the microorganisms involved in Spallanzani's and Pasteur's experiments were unicellular organisms.

The organisms you are most familiar with—for example, animals and plants—are multicellular. You can see one type of multicellular organism in **Figure 1–15.** (The Latin prefix *multi-* means "many." Thus, *multicellular* means "many-celled.") Multicellular organisms contain hundreds, thousands, or even trillions of cells. The cells in these organisms are often remarkably diverse, existing in a variety of sizes and shapes. In some multicellular organisms, each type of cell is specialized to perform a different function. The human body alone is made up of at least 85 different cell types. You will learn more about cells in Chapter 7.



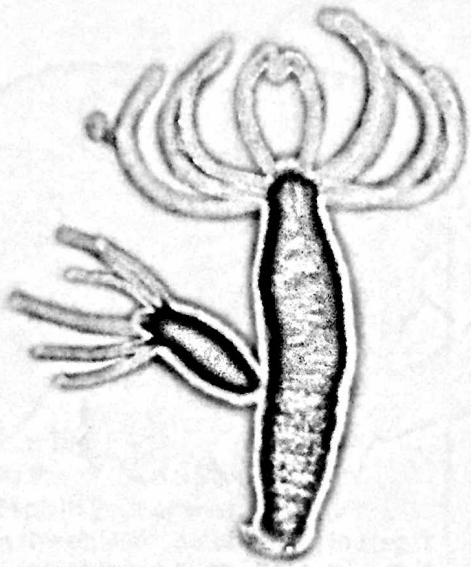
▲ **Figure 1–15 Living things are made of cells.** Cats and most other familiar organisms are made of many cells. The inset shows cells from a cat's stomach (magnification: 500×).

Reproduction All organisms produce new organisms through a process called reproduction. There are two basic kinds of reproduction: sexual and asexual. The vast majority of multicellular organisms—from maple trees to birds and humans—reproduce sexually. In **sexual reproduction,** cells from two different parents unite to produce the first cell of the new organism. In **asexual reproduction,** the new organism has a single parent. In some forms of asexual reproduction, a single-celled organism divides in half to form two new organisms. In the type of asexual reproduction shown in **Figure 1–16,** a portion of an organism splits off to form a new organism.

CHECKPOINT *What is sexual reproduction?*

Based on a Genetic Code Offspring usually resemble their parents. With asexual reproduction, offspring and their parents have the same traits. With sexual reproduction, offspring differ from their parents in some ways. However, there are limits to these differences. Flies produce flies, dogs produce dogs, and seeds from maple trees produce maple trees.

Explaining how organisms inherit traits is one of the greatest achievements of modern biology. Biologists now know that the directions for inheritance are carried by a molecule called deoxyribonucleic acid, or DNA. This genetic code, with a few minor variations, determines the inherited traits of every organism on Earth. You will learn how this is possible in Unit 4.



▲ **Figure 1–16 All living things reproduce.** Here, one hydra is being formed from another through a type of asexual reproduction called budding. Shortly, the new organism will break away from the parent and live independently.

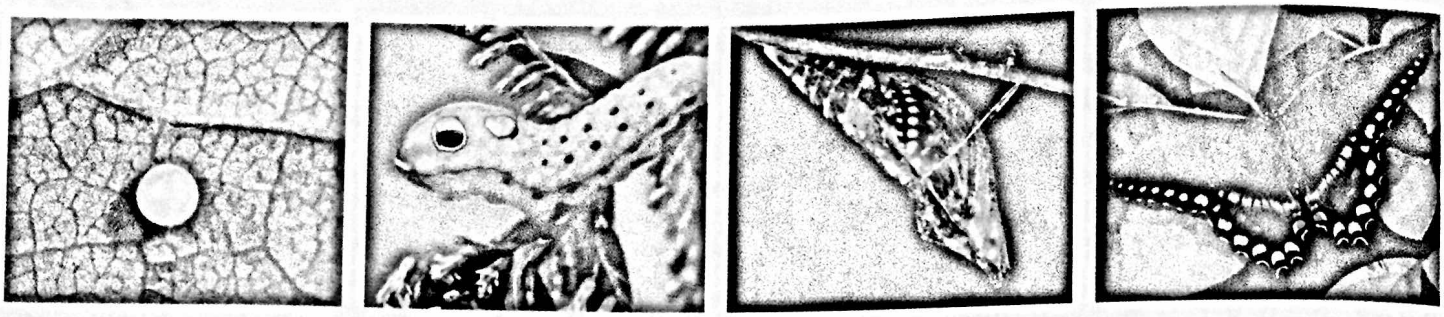


Figure 1–17 All living things grow and develop. These photographs show how a spicebush swallowtail butterfly develops from an egg into a caterpillar (larva), a pupa, and, finally, an adult butterfly.

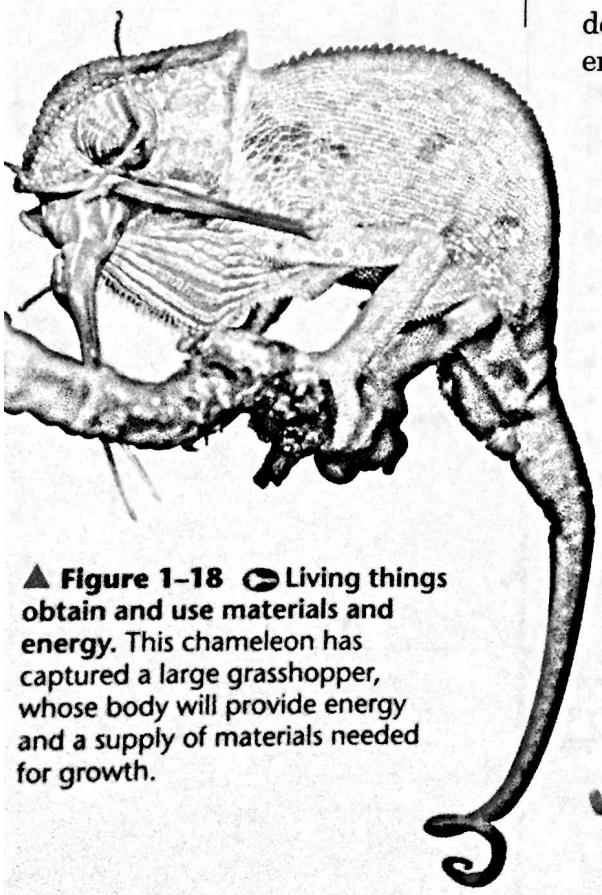
Growth and Development All living things grow during at least part of their lives. For some single-celled organisms, such as bacteria, growth is mostly a simple increase in size. Multicellular organisms, however, typically go through a process called development. During development, a single fertilized egg cell divides again and again to produce the many cells of mature organisms. As those cells divide, they change in shape and structure to form cells such as liver cells, brain cells, and muscle cells. This process is called differentiation, because it forms cells that look different from one another and perform different functions.

For many organisms, development includes periods of rapid and dramatic change, as shown in **Figure 1–17.** In fact, although you will not sprout wings, your body is currently experiencing one of the most intense spurts of growth and development of your entire life!

Need for Materials and Energy Think of what an organism needs as it grows and develops. Just as a building grows taller because workers use energy to assemble new materials, an organism uses energy and a constant supply of materials to grow, develop, and reproduce. Organisms also need materials and energy just to stay alive. The combination of chemical reactions through which an organism builds up or breaks down materials as it carries out its life processes is called **metabolism.**

All organisms take in selected materials that they need from their surroundings, or environment, but the way they obtain energy varies. Plants, some bacteria, and most algae obtain their energy directly from sunlight. Through a process called photosynthesis, these organisms convert light into a form of energy that is stored in certain molecules. That stored energy is ready to be used when needed.

Most other organisms rely on the energy stored during photosynthesis. Some organisms, such as grasshoppers and sheep, obtain their energy by eating plants and other photosynthesizing organisms. Other organisms, such as birds and wolves, get energy by eating the grasshoppers or sheep. The chameleon in **Figure 1–18** gets the materials it needs by eating insects and other small animals. And some organisms, called decomposers, obtain energy from the remains of organisms that have died.



▲ **Figure 1–18 Living things obtain and use materials and energy.** This chameleon has captured a large grasshopper, whose body will provide energy and a supply of materials needed for growth.

CHECKPOINT *What is metabolism?*

Response to the Environment Organisms detect and respond to stimuli from their environment. A **stimulus** is a signal to which an organism responds. External stimuli, which come from the environment outside an organism, include factors such as light and temperature. For example, when there is sufficient water and the ground is warm enough, a plant seed responds by germinating. The roots respond to gravity and grow down into the soil. The new leaves and stems grow toward light. In contrast, internal stimuli come from within an organism. The level of the sugar glucose in your blood is an example of an internal stimulus. If this level becomes low enough, your body responds by making you feel hungry.

Maintaining Internal Balance Even though conditions in the external environment may vary widely, most organisms must keep internal conditions, such as temperature and water content, fairly constant to survive. The process by which they do this is called **homeostasis** (hoh-mee-oh-STAY-sis). Homeostasis often involves internal feedback mechanisms that work in much the same way as a thermostat. Just as a thermostat in your home turns on the heat when room temperature drops below a certain point, you have an internal "thermostat" that makes your body shiver if your internal temperature drops too low. The muscle action involved in shivering produces heat, thus warming your body. In contrast, if you get too hot, your biological thermostat turns on "air conditioning" by causing you to sweat. Sweating helps to remove excess heat from your skin. When birds get cold, they hunch down and adjust their feathers to provide maximum insulation, as shown in **Figure 1–19.** Often internal stimuli help maintain homeostasis. For example, when your body needs more water to maintain homeostasis, internal stimuli make you feel thirsty.

▲ **Figure 1–19** **Living things maintain an internal stability.** Despite the cold temperatures of this robin's environment, its body temperature remains fairly constant, partly because its feathers provide a layer of insulation and partly because of the body heat it produces.

Quick Lab

What are the characteristics of living things?

Materials hand lens, unknown objects (dry), same objects soaked in water

Procedure

1. Examine the dry unknown object your teacher provides. Record your observations.
2. **Predicting** In step 3, you will observe the same kind of object after it has been soaked in water. Write a prediction describing what you expect to see.
3. Examine one of the objects that has been soaking in water for a period of time. Record your observations. Wash your hands when you have finished.

Analyze and Conclude

1. **Evaluating** Was the prediction you made in step 2 correct? Explain your answer.
2. **Inferring** Were the objects you observed in step 1 living or nonliving? Were the objects you observed in step 3 living or nonliving? Use the observations you made as supporting evidence for your answers.
3. **Formulating Hypotheses** Suggest one or more ways to explain the differences between the dry and wet objects.