Chapter

2 Biology as a Science

These bristlecone pine trees in the White Mountains of California are among the oldest living organisms on Earth. Some of these trees have been alive for more than 4000 years.

Chapter Inquiry Posing Questions

1. Look at the various photographs your teacher has provided.

2. Choose one photograph and examine the organisms shown.

3. Make a list of the 10 questions that a biologist might ask about these organisms.

Connect to the Main Ideas

How do you know that these are photographs of living organisms? List five characteristics they have in common.

GUIDE FOR READING

After you read the following sections, you will be able to

2–1 Characteristics of Living Things

- List and describe the characteristics of living things.
- Define homeostasis and explain why it is important to living things.

2–2 Biology: The Study of Life

- Discuss the different branches of biology and the levels of phenomena studied by biologists.
- Describe and compare different kinds of microscopes.
- Relate specific laboratory techniques to biology.

Journal Activity

YOU AND YOUR WORLD

What do you think living things would be like on another planet? Do you think human space explorers would immediately recognize these alien life forms as being alive? In your journal, explore your ideas in the form of a short story or essay.

2–1 Characteristics of Living Things

Guide For Reading

- What are the characteristics of living things?
- What is homeostasis?

Making up a list of the characteristics of living things is not as easy as it might sound. In fact, scientists have argued for centuries over the basic characteristics that separate life and nonlife. Some of these arguments are still unresolved. For example, in Chapter 17 you will discover that the line between life and nonlife becomes blurred when we consider whether or not viruses are living things.

Despite these arguments, there do seem to be some generally accepted characteristics common to all living things. **We can state with some confidence that all living things**

- **Are made up of one or more units called cells**
- **Reproduce**
- **Grow and develop**
- **Obtain and use energy**
- **Respond to their environment**

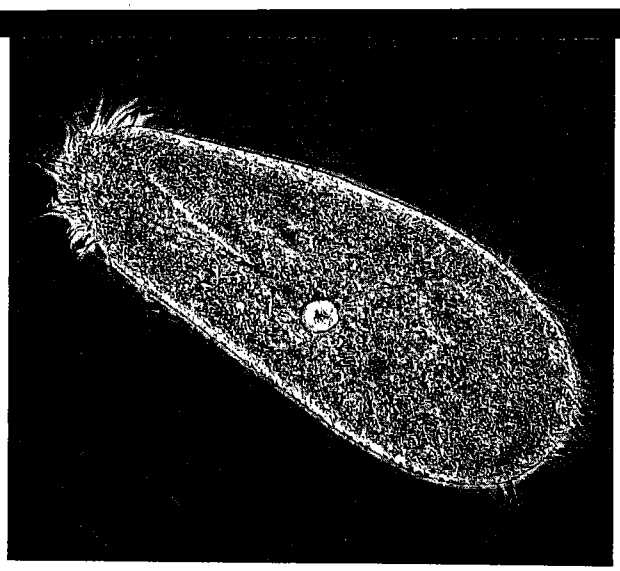
It will help in our understanding of living things to consider each of these characteristics in detail.

Living Things Are Made Up of Cells

Living things are made up of small self-contained units called cells. Each cell is a collection of living matter enclosed by a barrier that separates the cell from its surroundings. Most cells can perform all the functions we associate with life.

Cells are remarkably diverse. A single cell by itself can form an entire living organism. Organisms consisting of only a

Figure 2–1 *This* Lithops *plant, commonly called the living stone, certainly does not appear to be alive (left). Yet you would have no trouble determining that it is a living organism if you saw it flowering (right).*



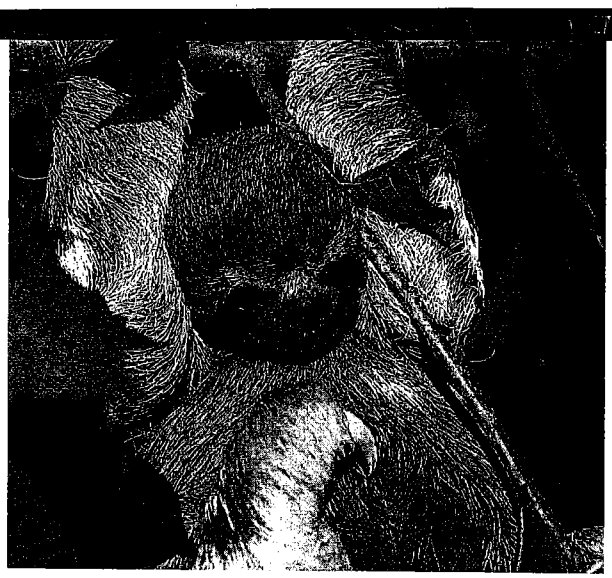
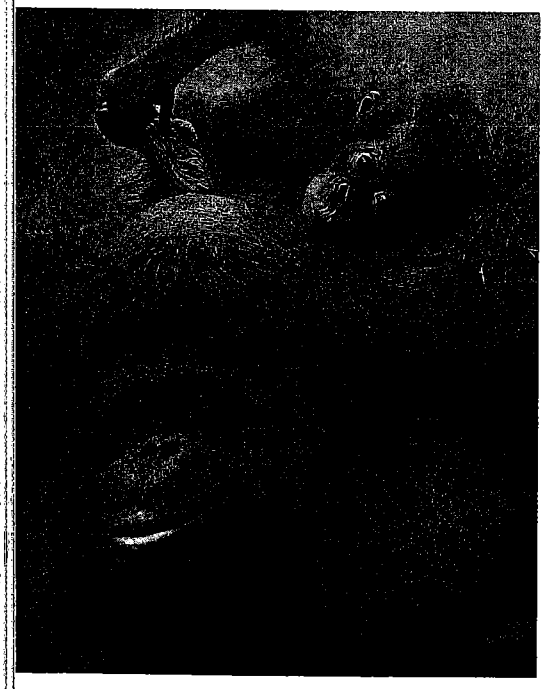


Figure 2–2 *Biologists classify organisms as unicellular or multicellular. This unicellular protozoan (left) is a single-celled organism, whereas the multicellular tree sloth (right) is made up of trillions of cells.*

single cell are called **unicellular**. See Figure 2–2. (The Latin prefix *uni-* means one, so unicellular means single-celled.) Most of the organisms you are familiar with, such as dogs and trees, are **multicellular**. (The Latin prefix *multi-* means many, so multicellular means many-celled.) Multicellular organisms contain hundreds, thousands, even trillions of cells or more. We will discuss cells in more detail in Chapter 5.

Cells are not found in nonliving matter unless that matter was once alive. Wood, for example, is made up largely of the walls that once separated the individual cells in the living tree.

Figure 2–3 *Orangutans, like many other animals, reproduce sexually. In sexual reproduction, one cell from each parent unites to form the first cell of the new organism.*



Living Things Reproduce

Living things can reproduce, or produce new organisms of the same type. Because all individual organisms eventually die, reproduction is necessary if a group of similar organisms (what we will later call a species) is to survive.

There are two basic kinds of reproduction: sexual and asexual. **Sexual reproduction** requires that two cells from different individuals unite to produce the first cell of a new organism. See Figure 2–3. You are reading this textbook because a cell from your mother united with a cell from your father to form that first cell that would grow and develop into you. Most familiar organisms—from maple trees to birds and bees—reproduce sexually. In **asexual reproduction**, a single organism can reproduce without the aid of another. (The prefix *a-* means without, so asexual means without sex.) Asexual reproduction can be very simple: Some single-celled organisms merely divide in two to form two organisms.

Living Things Grow and Develop

All living things, at one stage or another in their lives, are capable of growth. An acorn, when it sprouts, produces roots, stems, a trunk, and leaves that continue to grow for years. As it grows, the plant takes in substances from the air and soil and

Figure 2–4 *All living things grow and develop. Usually growth simply means getting larger, not changing form. But that is not always the case. This caterpillar (left) will grow and develop into an adult* Cecropia *moth (right).*

transforms these substances into living tissue. And long after the tree stops getting larger, it continues to add new material to replace existing parts that wear out.

A snowball, on the other hand, may seem to "grow" if you roll it over fresh snow. But a snowball grows bigger only if someone adds new snow onto its surface. A snowball won't grow bigger by just sitting there. And it certainly cannot change liquid water or solid ice into new snow from which it can grow larger.

During growth, most living things go through a cycle of change called development. The single cell that starts an organism's life divides and changes again and again to form the many and varied cells of an adult organism. You are probably well aware of growth and development since you are now in the midst of one of the most intense spurts of growth and development that you will ever encounter in your life.

As development continues, organisms experience a process called aging. During aging, an organism becomes less efficient at the process of life. The ability to reproduce comes to an end. For virtually all organisms, death is the inevitable end of the life span of every individual. Death, too, is a process of change that separates living and nonliving things.

Figure 2–5 *According to this chart, what is the maximum life span of a blue whale?*

MAXIMUM LIFE SPANS

Organism	Life Span
Adult mayfly	1 day
Marigold	8 months
Mouse	1–2 years
Dog	17 years
Blue whale	100 years
Tortoise	152 years
Bristlecone pine	5500 years

Living Things Obtain and Use Energy

Living things obtain energy from their environment, or their surroundings, and use that energy to grow, develop, and reproduce. All organisms require energy to build the substances that make up their cells. Any process in a living thing that involves putting together, or synthesizing, complex substances from simpler substances is called **anabolism** (uh-NAB-uh-lihz-uhm).

Plants obtain their energy from sunlight in a process called photosynthesis, which you will study in Chapter 6. (The prefix *photo-* refers to light, and the suffix *-synthesis* means put together. Thus photosynthesis means put together with light.)

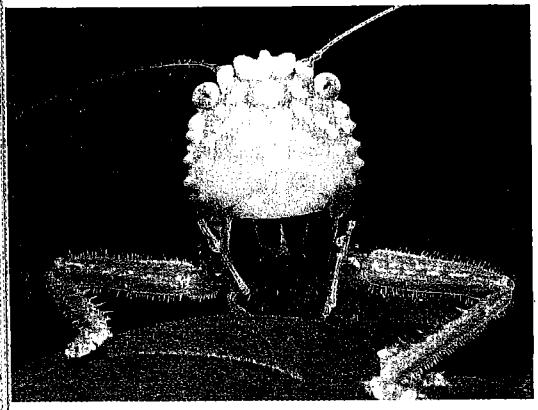


Figure 2–6 This katydid obtains the energy it needs to live from the food it eats. How does the green plant the katydid is munching on obtain its energy?

Animals cannot perform photosynthesis. Animals take in energy in the form of food. Food is broken down during a process called digestion, which you will study in Chapter 39. The final breakdown of complex substances into simpler ones, usually resulting in the release of energy, is called **catabolism** (kuh-TAB-uh-lihz-uhm).

Living things must practice both anabolism and catabolism at the same time, just as a business or a household must take some money in as income and pay some money out as expenses. The total sum of all chemical reactions in the body—the balance of anabolism and catabolism—is called **metabolism**.

Living Things Respond to Their Environment

Living things respond to their environment. Such responses can be rapid, usually through changes in behavior, or slow, usually through changes in metabolic processes or through growth. Anything in the environment that causes an organism to react is called a stimulus. Organisms react to many stimuli, including light, temperature, odor, sound, gravity, heat, water, and pressure. What stimuli are you responding to at this very moment?

The ability of living things to react to stimuli is known as irritability. (No, that does not mean that living things are grouchy. At least not all the time!) Both plants and animals exhibit irritability and can react to a variety of stimuli. Plants, however, usually respond to stimuli more slowly than animals. Plant leaves and stems, for example, grow toward light and away from the pull of gravity. Plant roots, on the other hand, respond to gravity by growing down into the soil.

In general, living things respond to stimuli in ways that improve their chances for survival. **The process by which organisms respond to stimuli in ways that keep conditions in their body suitable for life is called homeostasis**. (The prefix

Figure 2–7 Living things respond to stimuli from their environment. What stimuli is the bat responding to? What will be the logical response of the frog?

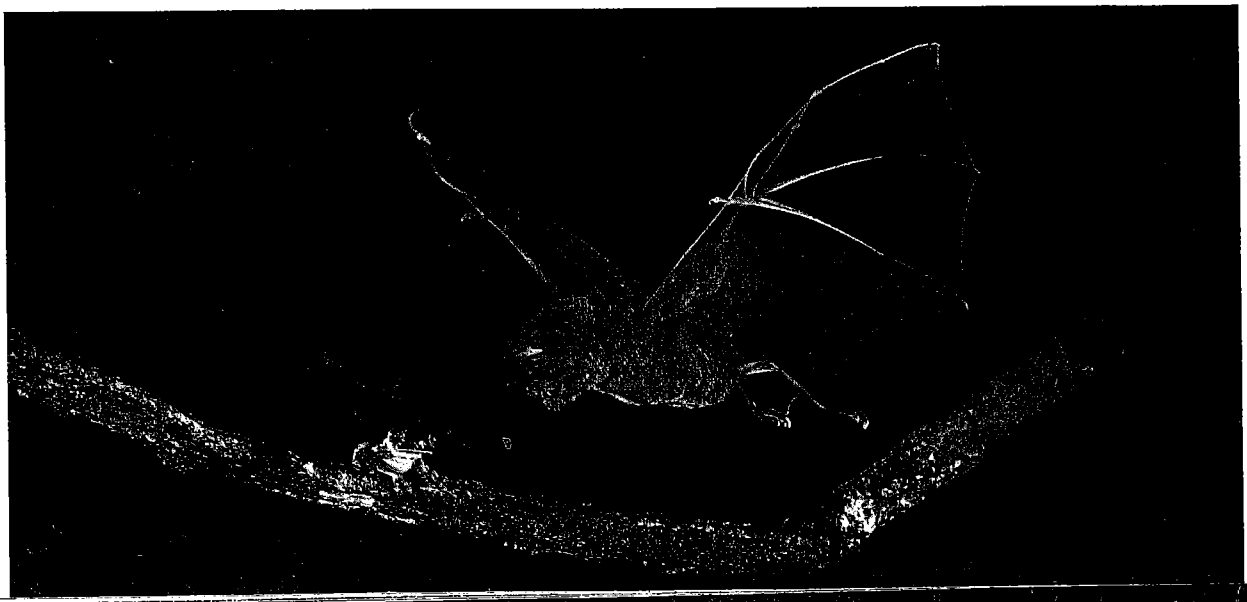


Figure 2–8 *This Australian reptile, called the frilled dragon, is basking on a rock in the sun. How does this behavior of the reptile help it achieve homeostasis? What might the reptile do if its body overheats?*

homeo- means similar or same. The suffix *-stasis* means standing or stopping.) **Homeostasis** (hoh-mee-oh-STAY-sihs) refers to an organism's ability to maintain constant or stable conditions that are necessary for life. Just as a thermostat in your home turns on the heat when it gets down to a certain temperature, your body has a thermostat that maintains a constant internal temperature. If you get too hot, you sweat and cool off. And if you sweat for a long time, the resulting thirst persuades you to replace the water your body has lost.

You might point out that nonliving things also respond to the environment. However, the responses of nonliving things are purely mechanical (like a spring that jumps when compressed and released) and are not related to survival.

2–1 SECTION REVIEW

1. Describe five characteristics of living things.
2. Compare sexual reproduction and asexual reproduction.
3. Define metabolism, using the terms catabolism and anabolism in your definition.
4. **Critical Thinking—Making Generalizations** Try to think of a nonliving thing that satisfies each characteristic of living things. Does any nonliving thing have all the characteristics of life?

2–2 Biology: The Study of Life

Guide For Reading

- What are the types of questions asked by different kinds of biologists?
- What kinds of microscopes are used by biologists? What are the advantages and disadvantages of using the different kinds of microscopes?
- What are some laboratory techniques used in biology?

Quite literally, biology means the study of life. (The prefix *bio-* means life, and the suffix *-logy* means study of.) Biology, then, is the science that seeks to understand, explain, and even control the living world. Biology, like any other science, advances by observing the world, asking questions, and forming hypotheses that can be tested by experiment. **A biologist is anyone who uses the scientific method to study living things.**