The Nature of Life

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A starfish moves along living coral, bathed by a salty sea. Fish flash exotic colors, and a crab crawls on the ocean floor. Somewhere far off, a lizard scurries across desert sand, and a sidewinder snake lives up to its name. In still another setting, sidewalk cracks go green with life while ants make pie-shaped mounds. Life is everywhere, in forms incredibly diverse. But what is life? In this chapter, you will learn how biologists answer that difficult question.

Guide for Reading

Key words: biology, organism, homeostasis, nutrition, transport, respiration, growth, reproduction, metabolism

Questions to think about:

- What are the characteristics of life?
- What are the functions of each of the life processes?
- What is homeostasis?

1-1 Understanding Life

Section Objectives:

- *Identify* some unifying themes in biology.
- *List* nine general characteristics that distinguish living from nonliving things.

Laboratory Investigation: *Observe* and *compare* living and nonliving specimens (p. 9).

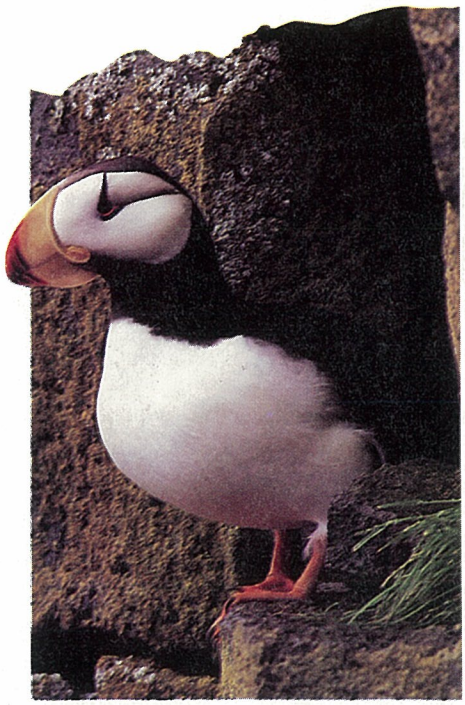
The word **biology** is easy to define. It is the study of living things. Although biology is unique, it is not an isolated science. You will discover, for example, that information and ideas from chemistry, physics, and geology appear throughout your biology text. Scientists think that biology is linked to other sciences by major unifying themes, or big ideas.

Unifying Themes

Energy Organisms require energy to grow and to reproduce. Just as a car stops when there is no gasoline to fuel its engine, an organism dies when no energy is available to carry out its life processes.

Evolution In biology, evolution, or changes in living things through time, explains the inherited similarities as well as the diversity in all forms of life. Evolution, which is explained in detail in Unit 6, is the major unifying theme of biology.

Patterns of Change Scientists try to make sense of change by



▲ **Figure 1–1**

An Organism. This horned puffin shares many characteristics with all other living things.

▲ **Figure 1–2**
Signs of Life in a Forest. A forest during the growing season (left) shows obvious signs of life. During winter (right), the same forest may appear to be dead.

noting cycles, trends, or random events that occur before or during change. For example, all living things, including humans, have a life cycle.

Scale and Structure Living things are described in terms of their structures and levels of organization. At one level of organization, for example, you might describe the main structures of a green plant—its roots, stems, and leaves; at another level, you might describe the cells in each of these structures.

Systems and Interactions Examples of biological systems include ecosystems, in which communities of organisms interact with the environment, and human body systems, in which organs interact to carry on life functions.

Stability Biological systems tend to achieve a stable equilibrium. A good example of this kind of stability is your body temperature, which tends to remain constant.

Environment All the external factors that make up an organism's surroundings make up its environment. Organisms interact with their environment and have an impact on it.

Unity and Diversity Although each life form, from the ameba to the great blue whale, differs in appearance and organization (diversity), it also displays certain similarities to other organisms (unity). We begin the study of biology by talking about the most basic similarities: the general characteristics of life.

Characteristics of Life

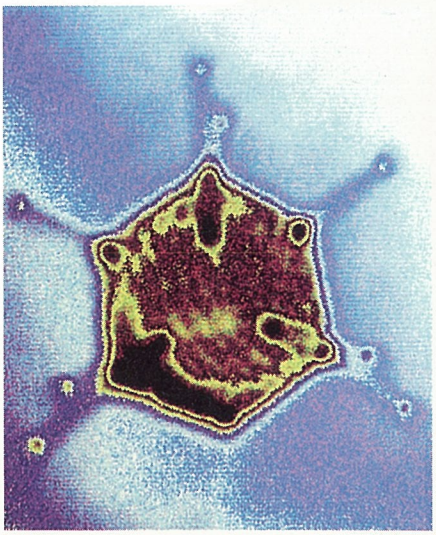
What do you mean when you say that something is alive? Look at the photo on the left in Figure 1-2. Do you see a dead tree? What makes you think it is dead? Now look at the photo on the right. Are all these trees dead? Although they look like the dead tree, they are

probably not dead. In the spring, tiny buds at the ends of twigs will grow into leaves.

The growth of new leaves is a sign of life. What other signs of life can you think of? Biologists have not been able to agree on a simple definition of life. But they have agreed on what the "signs of life" are. Taken together, these signs can become a definition of life.

Each living thing is called an **organism** (OR guh nih zum). Organisms have all the following characteristics: ▪ Living things are highly organized and contain many complex chemical substances. ▪ Living things are made up of one or more cells, which are the smallest units that can be said to be alive. ▪ Living things use energy. ▪ Living things have a definite form and a limited size. ▪ Living things have a limited life span. ▪ Living things grow. ▪ Living things respond to changes in the environment. ▪ Living things are able to reproduce. ▪ Groups of living things evolve, or change, over time.

Non-living objects may show one or a few of these characteristics, but they never show all of them. In some borderline cases, however, it may not be clear whether an object is living or nonliving. One example is the virus. Viruses can be stored like chemicals in a bottle but, when inside living cells, can reproduce. Even so, viruses do not exhibit most of the other characteristics of living things.



1-1 Section Review

1. Define the term *organism.*
2. What are three unifying themes in biology?
3. Name three characteristics of life.

Critical Thinking

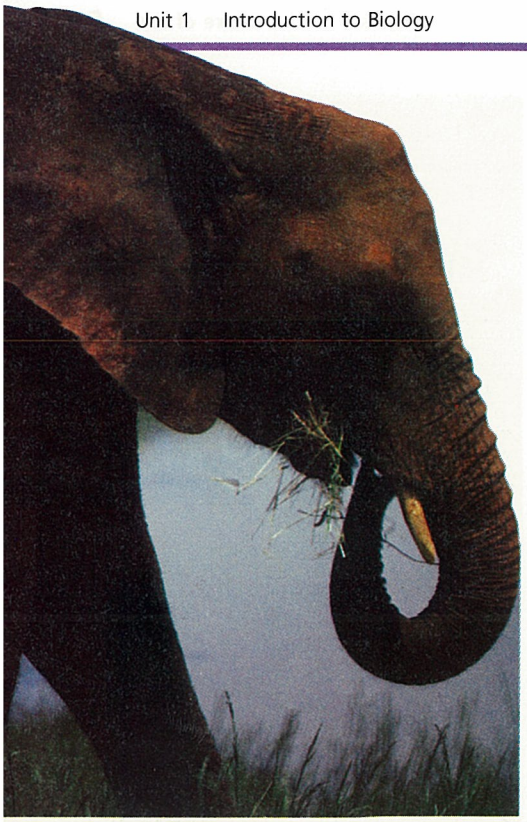
4. Look back over the list of the characteristics of life. Which characteristics are found *only* in living things? Which are found in both living and nonliving things? (Classifying)

1-2 Life Processes

Section Objectives:

- *Name* and *define* eight general processes by which the life of an organism is maintained.
- *Define* the term *metabolism.*

Living things carry out many different kinds of processes. Some of these processes, such as growth, reproduction, and the use of energy, already have been discussed as basic characteristics of life. These, of course, are not the only processes carried out by living things. Biologists have identified a number of other general processes that relate to the functioning of living things. Many of these



▲ **Figure 1–4**
Nutrition in Animals. All animals must obtain food by ingesting other organisms.

life processes are necessary for maintaining a fairly constant environment within an organism in spite of its constantly changing external environment. The condition of a constant internal environment is known as **homeostasis** (hoh mee oh STAY sis).

Nutrition

Every organism takes materials from its external environment and changes them into forms it can use. This activity is called **nutrition. Nutrients** (NOO tree unts) are the substances that an organism needs for energy, growth, repair, or maintenance.

There are only two basic types of nutrition. In one type, the organism can produce complex nutrients from simple substances found in the environment. All green plants and some bacteria and other one-celled organisms are able to make their own nutrients in this way.

In the second type, organisms that cannot make their own nutrients obtain them ready-made from the environment. Animals, for example, get their nutrients by eating other organisms in their environment.

The taking in of food from the environment is called **ingestion.** Usually, the nutrients in food are not in forms that an organism can use directly. They are too complex chemically, and the organism must break them into simpler forms. The breakdown of complex food materials into simpler forms that an organism can use is called **digestion.**

Transport

The process by which substances enter and leave cells and become distributed within the cells is known as **transport.** In the smallest and simplest organisms, materials are exchanged directly with the external environment. Usable materials enter the cells directly from the environment; waste materials pass from cells directly into the environment.

In larger, multicellular organisms, however, most cells are not in direct contact with the external environment. In many animals, for example, a *circulatory system* transports materials to, and wastes away from, the cells of the organism. The fluid, or blood, of the circulatory system is kept in motion, distributing these materials among the cells of the organism. In plants, specialized conducting structures transport substances from the roots and leaves to all parts of the plant.

Respiration

All life processes require a constant supply of energy. Organisms obtain their energy by releasing the chemical energy stored in nutrients. The process of releasing chemical energy is called **respiration** (res puh RAY shun).

Respiration involves a complex series of chemical reactions. In one type of respiration, sugar or another food substance is broken down to produce water and carbon dioxide. This process requires oxygen from the air and is known as *aerobic respiration.* Some organisms break down food without using oxygen. This is called *anaerobic respiration.*

Synthesis and Assimilation

Organisms are able to combine simple substances chemically to form more complex substances. This process is called **synthesis** (SIN thuh sis). Usually, in animals, the substances used in synthesis are the products of digestion.

Synthesis produces materials that can become part of the structure of an organism. In this way, the organism can repair or replace worn-out parts. These materials also allow the organism to grow. The incorporation of materials into the organism's body is called **assimilation** (uh sim uh LAY shun).

Growth

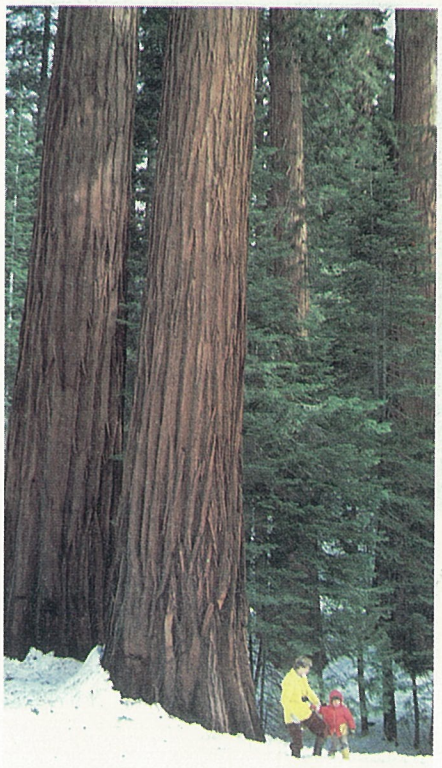
The process by which living organisms increase in size is called **growth.** It is one result of the assimilation of nutrients. In one-celled organisms, growth is simply an increase in the size of the cell. In organisms made up of many cells, growth is usually the result of an increase in both the number and the size of cells. Growth in multicellular organisms is accompanied by *cellular specialization.* This process involves different cells becoming specialized for different functions. In animals, growth usually follows a particular pattern and ends after a certain period of time. Some plants, however, continue growing indefinitely.

Excretion

Every organism produces waste substances that it cannot use and that may be harmful if accumulated in the body. These wastes are the products of many of the chemical reactions that occur within cells. The removal of these wastes from the organism's body is called **excretion.**

Regulation

All the activities that help to maintain an organism's homeostasis make up the process of **regulation.** In animals, systems such as the digestive, transport, excretory, nervous, and endocrine (EN duh krin) systems are involved in some part of the process of regulation. Each of these systems contributes to maintaining homeostasis. The digestive system allows an animal to provide nutrients to its body. The transport system ensures that all areas of the body are constantly supplied with necessary materials. The excretory system removes wastes that are produced in the body.



▲ **Figure 1–5**

Growth. This tiny sequoia seedling (top) can grow into a mature tree with a height of over 100 meters (bottom).

▲ **Figure 1–6**
Reproduction. In one type of asexual reproduction, the plantlets on the leaf's edge (top) fall off and grow into new plants. Sexual reproduction (bottom) involves two parents.

The nervous and endocrine systems regulate these systems. The nervous system carries messages—nerve impulses—throughout the body through a network of specialized cells. The endocrine system is made up of a number of organs that release chemicals, called *hormones,* into the bloodstream. Hormones act as chemical messengers. Both nerve impulses and hormones can bring about changes in the organism in response to changes in either the internal or the external environment.

Plants do not have nervous systems, but they do have parts that produce hormones. These hormones allow a plant to respond to various changes in its environment.

Reproduction

Reproduction is the process by which living things produce new organisms of their own kind. Reproduction is not necessary for the continued life of a single organism. However, it is necessary for the continued existence of that kind of organism.

There are two types of reproduction—**asexual** (ay SEK shuh wul), or *vegetative,* **reproduction** and **sexual reproduction** (see Figure 1-6). In asexual reproduction, a single individual produces offspring that are identical to that parent. In sexual reproduction, there are two parents, and the offspring are not identical to either parent.

Metabolism

All the chemical reactions occurring within the cells of an organism are called its **metabolism** (muh TAB uh liz um). Metabolism includes processes that build complex substances from simpler ones and processes that break down complex substances into simpler ones. Metabolism also involves the continuous release and use of energy. Many biologists consider metabolic activity to be the single most important characteristic of life.

1-2 Section Review

1. What life process involves obtaining material and changing it into useful forms?
2. Name the process by which organisms release chemical energy from nutrients.
3. Define the term *growth.*
4. What is homeostasis?

Critical Thinking

5. How is the transport system in your community (roads, sidewalks, etc.) similar to the transport system in your body? How do these systems differ? (*Comparing and Contrasting*)