Chapter 1

THE NATURE OF LIFE

When a cougar chases its prey, it displays the ability to respond to its environment.

DESCRIBING LIFE

Objective:

List nine general characteristics that distinguish living from nonliving things.

The word **biology** is easy to define. It is the study of living things. Let us consider what this might mean. Think for a minute or two about the different kinds of living things you know by sight. You may want to jot them down under various headings, such as domestic animals, wild animals, ocean life, insects. Don't forget the plants you know—for example, trees, wildflowers, garden flowers, house plants, weeds. If you take the time to do it, you may come up with quite a long list—probably 100 kinds, at least.

Suppose you wanted to find out everything you could about the living things you know. You might expect it to take quite a long time. Yet, the living things you know are only a tiny fraction of all that exist. Biologists have found more than a million different kinds of life on earth. You may wonder how you can possibly learn very much about a million different things in one year of biology.

Actually, you are going to learn a great deal about every one of them by reading just a few pages of this chapter. The reason is that despite the great *diversity* of life, there is also a great *unity* of life. All living things are alike in many ways. We are going to begin the study of biology by talking about these similarities.

Figure 1-1. Temperate Forest in Summer.

1-1 Characteristics of Life

Just what do we mean when we say that something is alive? Look at Figure 1-1. It is a fairly common sight—the edge of a woods. Do you see a dead tree in the picture? What makes you think so?

Now look at Figure 1-2. This is a similar scene during the winter in one of the colder parts of the country. Are all these trees dead? They certainly look like the dead tree in Figure 1-1. But they are probably not dead. In the spring, tiny buds at the ends of twigs will grow into leaves. The trees will once again show signs of life.

Figure 1-2. Temperate Forest in Winter.

The growth of new leaves on a tree 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 that fits all cases. But they have agreed on what the "signs of life" are. Taken together, these characteristics or activities become the definition of life.

Each individual living thing is called an **organism** (*or*-guh-nih-zum). All organisms have the following characteristics.

1. Living things are highly organized and contain many complex chemical substances.
2. Living things are made up of one or more **cells,** which are the smallest units that can be said to be alive.
3. Living things use energy.
4. Living things have a definite form and a limited size.
5. Living things have a limited life span.
6. Living things grow.
7. Living things respond to changes in the environment.
8. Living things reproduce.
9. Groups of living things *evolve,* or change over time.

Nonliving objects may show one, or even a few, of these characteristics, but they never show all of them.

1-2 Borderline Cases

It is a human trait to try to define and classify the things we find in the world around us. But the world doesn't seem to be made to suit our wishes. Our definitions and classifications often have fuzzy edges. There are usually borderline cases that fit partly into one category and partly into another. This is especially true of our attempts to define life. There are things in the world that cannot clearly be called "living" or "nonliving." One example is the *viruses*—objects that can be stored like chemicals in a bottle, but when inside a living cell can reproduce more of themselves. Viruses can reproduce, but they do not otherwise carry on any of the processes of life. Another example is a plant seed. Many seeds can be kept in a package for years without undergoing any change. When supplied with water and other suitable conditions, they develop into living plants. Is the seed in the package alive?

The best answer to the question may be that it doesn't really matter whether we say a seed is living or not. There is a far more important and, we think, more interesting question: How does a seed develop into a living plant? You will be trying to answer this kind of question in your study of biology.

THE LIFE PROCESSES

Objectives:

1. Name and define eight general processes by which the life of organisms is maintained.
2. Define the term *metabolism.*

We have mentioned some of the general characteristics of living things. Living things carry on certain activities that are also characteristics of life. In this section we will briefly describe the functions or processes that organisms perform in order to stay alive. These life processes are nutrition, transport, respiration, synthesis and assimilation, growth, excretion, regulation, and reproduction. We will find as we go along that everything we learn about living things is related in some way to these life processes. No matter how different individual organisms may be, they all must carry out these activities. This is the common thread that ties all living things together and makes them basically alike.

1-3 Nutrition

Every organism takes materials from its environment and changes them into forms it can use. This activity is called **nutrition** (noo-*trish*-un). Substances that an organism needs for energy, growth, repair, or maintenance are called **nutrients** (*noo*-tree-unts).

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

Organisms that cannot make their own nutrients must obtain them in the form of food from the environment. All animals must find their nutrients already made in their environment (see Figure 1-3).

The taking in of food from the environment is called **ingestion** (in-*jes*-chun). Generally, the nutrients in food are not in forms that the organisms can use directly. The nutrients are chemically too complex, and the organism must first break them down into simpler forms. The breakdown of complex food materials into simpler forms that can be used by an organism is called **digestion** (dy-*jes*-chun). The elimination of indigestible material from the digestive tract is called **egestion** (ih-*jes*-chun).

Figure 1-3. Nutrition in Animals. All animals must obtain food from the environment.

1-4 Transport

Transport is the process by which substances taken into the organism (absorption) or produced within the organism are distributed throughout the organism (**circulation**). Nutrients, wastes, and other products of the life processes are transported from one place to another within the organism. In the smallest organisms there is no real transport system. Usable materials are absorbed directly into the organism from the environment. Wastes pass from the organism directly back to the environment. In most animals, there is a specialized circulatory system for carrying needed materials to all parts of the organism and carrying wastes away. In plants, there are specialized conducting structures that carry substances from the roots and leaves to all parts of the plant.

Career

Biological Photographer

Biological photographers use cameras and other photographic equipment to provide illustrations for scientific publications and research reports. The prints and slides they take of biological specimens are used for teaching purposes also, as in this text. Photographs of biological materials range from prints made of specimens through an electron microscope to shots of groups of plants or large animals. Thus, biological photographers work with a variety of equipment and in many different environments, from the laboratory to outdoor settings of all kinds. An important specialty in the field is photomicrography, in which black-and-white and color slides and prints are made of specimens through a light microscope.

The training required for biological photography usually includes post-high-school education, for in this field success depends on more than being just a competent photographer. Some knowledge of biological science also is required. Numerous 4-year colleges and junior colleges offer photographic training that can be taken simultaneously with courses in the biological and other sciences.

1-5 Respiration

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

Respiration involves a complex series of chemical reactions. In one type of respiration, sugar is broken down to produce water and carbon dioxide. This is called **aerobic** (er-*roh*-bik) **respiration** because it requires oxygen from the air. Some simple organisms carry on **anaerobic** (an-uh-*roh*-bik) **respiration**, which does not require oxygen.

1-6 Synthesis and Assimilation

Organisms are able to combine simple substances chemically to form more complex substances. This process is called **synthesis** (*sin*-thuh-sis). The substances used in synthesis are generally products of the digestion of complex food materials.

One of the results of synthesis is to produce materials that can become part of the structure of an organism. In this way, the organism can repair or replace worn-out parts and can also grow. The incorporation of materials into the body of the organism is called **assimilation** (uh-sim-uh-*lay*-shun).

1-7 Growth

Growth is the process by which living organisms increase in size. It is one result of 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 size of cells. Growth in multicellular organisms is accompanied by **differentiation,** the process whereby initially similar and unspecialized cells become specialized for specific functions. In animals, growth generally follows a particular pattern and ends after a certain period of time. Some plants, on the other hand, continue growing throughout life.

1-8 Excretion

Every organism produces waste substances that it cannot use and that may be harmful if allowed to accumulate in the body. The removal of these wastes is called **excretion** (ek-*skree*-shun).

1-9 Regulation

Regulation is the process by which an organism maintains a stable internal environment in a constantly changing external environment. The condition of a stable internal environment is called **homeostasis** (hoh-mee-oh-*stay*-sis).

In animals, regulation is accomplished primarily by the *nervous system,* the *endocrine* (*en*-duh-krin) *system,* and the

excretory system. The nervous system consists of a network of specialized cells that carry messages, or impulses, throughout the organism. The endocrine system consists of a number of glands that secrete chemicals called *hormones*. 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. There is no nervous system in plants, but there are parts of the plant that produce hormones. These hormones enable the plant to respond to various changes in the environment. The excretory system eliminates metabolic wastes from the body, helping to maintain the body's internal chemical balance.

1-10 Reproduction

Reproduction is the process by which living things produce new organisms of their own kind. Unlike the other life processes, reproduction is not necessary for the continued life of an individual 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) **reproduction** and **sexual** (*sek*-shuh-wul) **reproduction** (see Figure 1-4). In asexual reproduction there is only one parent, and all offspring are identical to that parent. In sexual reproduction there are two parents, and the offspring are not identical to either parent.

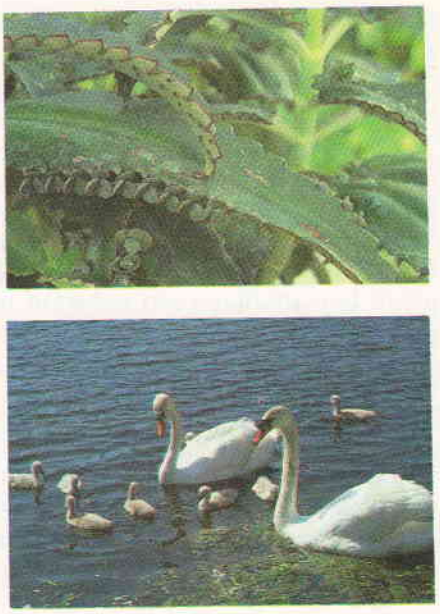

Figure 1-4. Types of Reproduction. In one type of asexual reproduction, the plantlets on the edge of the leaf (top) fall off and grow into new plants. In sexual reproduction, two parents share in the reproductive process. Some parents, like these swans (bottom), also share the task of raising the young.

1-11 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.

Chapter Review

SUMMARY

- Biology is the study of living things. There are more than a million different kinds of living things on earth. Although they vary in many respects, they all show certain basic characteristics that distinguish them from nonliving things.
- A few things, including viruses and seeds, are difficult to classify as either living or nonliving because they show characteristics of both.
- Living things carry on certain activities that are characteristics of life. These activities include nutrition, transport, respiration, synthesis and assimilation, growth, excretion, regulation, and reproduction. Metabolism includes all the chemical reactions of the life processes.