Chapter 1: Introduction to Biology and the Process of Science

Figure 1.1 This NASA image is a composite of several satellite-based views of Earth. (credit: modification of work by NASA/Concepts of Biology OpenStax)

Viewed from space, Earth offers very few clues about the diversity of life forms that can be found there. The first forms of life on Earth are thought to have been microorganisms that existed for billions of years before plants and animals appeared. Mammals, birds, and flowers are all relatively recent additions to the planet, originating 130 to 200 million years ago. Humans have only inhabited this planet for the last 2.5 million years, and only in the last 200,000 years have humans started looking like we do today.

1.1 Themes and Concepts of Biology

Learning objectives

By the end of this section, you will be able to:

- *Identify and describe the properties of life*
- *Describe the levels of organization among living organisms*
- *Understand the role of evolution as a unifying principle of biology and how it contributes to species diversity*
- *Understand how life is classified*
- *Be able to define and explain all bolded terms*

Biology is the science that studies life. What exactly is life? This may sound like a silly question with an obvious answer; however, it is not always easy to define life. For example, a branch of biology called virology studies viruses. Viruses exhibit some of the characteristics of life but lack others. It turns out that although viruses can attack living organisms, cause diseases, and even reproduce with the help of host cells, they do not meet all the criteria that biologists use to define life.

From its earliest beginnings, biology has wrestled with four questions: What are the shared properties that make something "alive"? How do those various living things function? Planet

earth has a diversity of life forms; how do we organize and classify these different organisms? Finally, how did this diversity arise, and how is it continuing? As new organisms are discovered every day, biologists continue to seek answers to these and other questions.

Properties of Life

All living organisms share the following key characteristics: order, response to stimuli, reproduction, adaptation, growth and development, homeostasis, and energy processing. These seven characteristics serve to define life. It is essential that students know these different properties of life and be able to explain each.

Order

Organisms are highly organized and consist of one or more cells. Even very simple, single-celled organisms are remarkably complex. Inside each cell, atoms come together through chemical bonding and form molecules. Molecules come together to form cell components or structures called organelles. Like the toad shown in Figure 1.2, multicellular organisms can consist of millions of cells. Different groups of cells then specialize in performing specific functions. Without order, specialization would not be possible.

Figure 1.2 A toad represents a highly organized individual. (credit: "Ivengo(RUS)"/Wikimedia Commons)

Response to Stimuli

Organisms respond to diverse stimuli. For example, plants can bend toward a source of light or respond to touch (Figure 1.3). Even tiny bacteria can move toward or away from chemicals, a process called chemotaxis. A movement toward a stimulus is considered a positive response, while movement away from a stimulus is regarded as a negative response.

Humans also respond to stimuli. For example, when we become warm on a hot sunny day, the body has tiny glands called sudoriferous, or sweat, glands that make and release sweat onto the skin's surface. The heat from the body can be transferred to the sweat, which acts as a cooling mechanism and helps to maintain constant body temperature.

Figure 1.3 The leaves of this sensitive plant (*Mimosa pudica*) will instantly droop and fold when touched. After a few minutes, the plant returns to its normal state. (credit: Alex Lomas/Concepts of Biology OpenStax)

CONCEPTS IN ACTION- Watch this video to see how the sensitive plant responds to a touch stimulus.

Reproduction

Reproduction is necessary on both a cellular and organismal level. For a population to survive, some individuals within that population must reproduce. Organisms that are multicellular, such as plants and animals, also need to reproduce on a cellular level. As old cells become damaged or worn out, they must be replaced by new cells. For example, skin cells are damaged continuously and need to be replaced every two to three weeks; otherwise, the skin would lose its ability to provide protection.

Single-celled organisms must also reproduce. Reproduction begins by first duplicating their genetic material. Once the genetic material is duplicated, it is then divided equally into two new cells (Figure 1.4). The two new daughter cells should be identical to the parent cell.

Figure 1.4 Bacteria cell going through division. (credit: Pradana Aumars/Wikimedia Commons)

Adaptation

All living organisms exhibit a "fit" to their environment. Biologists refer to this fit as adaptation. Adaptations are a consequence of evolution by natural selection. Evolution has had some impact on every lineage of reproducing organisms. Examples of adaptations are diverse and unique. For example, some microorganisms live in boiling hot springs, whereas some moths have tongues the exact length of the flower from which they feed.

Adaptations are vital because they enhance an individual's ability to survive and reproduce; however, adaptations are not constant. As an environment changes, natural selection causes the individuals in a population to adapt to those changes.

For example, imagine that there is a population of finches living on an island. An environmental event has resulted in two main food sources: soft insects and hard seeds. Not all finches within the population have the same beak length or size. Finches in the population that have long, skinny beaks begin to feed on soft insects because they are easy for those birds to catch and eat. Finches with large, more dense beaks feed on hard seeds because their dense beaks allow them to