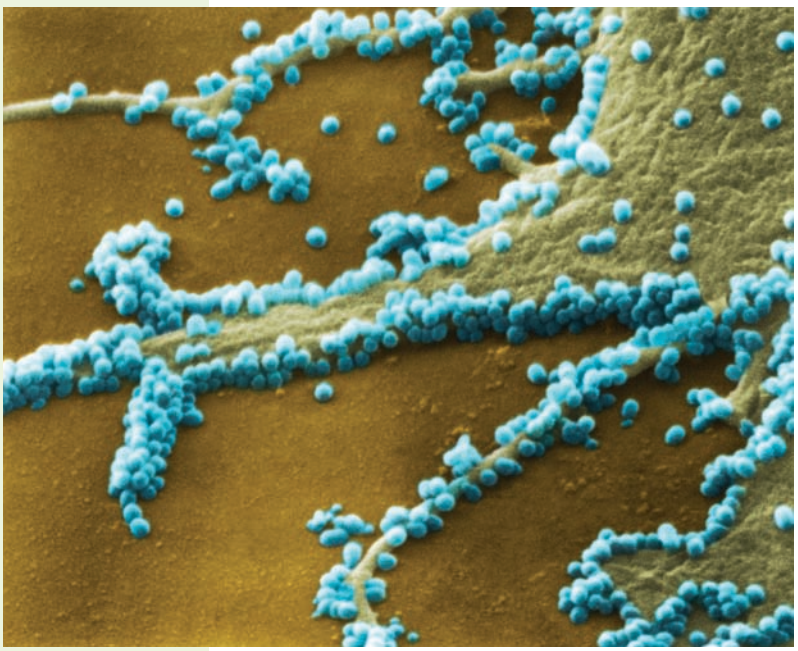
1 A View of Life



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H1N1, the virus that causes H1N1 influenza (flu). H1N1 virus particles (blue) are visible on a cell (green). When this virus emerged, the human immune system was unfamiliar with its new combination of genes. As a result, the virus spread easily, causing a pandemic. The scanning electron micrograph (SEM) has been color-enhanced.

KEY CONCEPTS

1.1 Basic themes of biology include evolution, information transfer, and energy transfer.

1.2 Characteristics of life include cellular structure, growth and development, self-regulated metabolism, response to stimuli, and reproduction.

1.3 Biological organization is hierarchical and includes chemical, cell, tissue, organ, organ system, and organism levels; ecological organization includes population, community, ecosystem, and biosphere levels.

1.4 Information transfer includes DNA transfer of information from one generation to the next; chemical and electrical signals within and among the cells of every organism; and chemicals, visual displays, and sounds that allow organisms to communicate with one another and to interact with their environment.

1.5 Individual organisms and entire ecosystems depend on a continuous input of energy. Energy is transferred within cells and from one organism to another.

1.6 Evolution is the process by which populations of organisms change over time, adapting to changes in their environment; the tree of life includes three major branches, or domains.

1.7 Biologists ask questions, develop hypotheses, make predictions, and collect data by careful observation and experiment; based on their results, they come to conclusions.

The H1N1 influenza (flu) outbreak became the focus of attention in April 2009. Within a few months, more than 200 countries around the world had reported confirmed cases of this viral disease, and H1N1 had caused thousands of deaths. According to the U.S. Centers for Disease Control and Prevention (CDC), more than 200 known pathogens (disease-causing organisms) have the potential to strike globally. Historically, new viral strains have claimed many human lives. For example, in 1918 an influenza pandemic killed more than 20 million people throughout the world. Epidemiologists warn that even today an influenza pandemic could kill millions of people. Pandemics such as H1N1 have negative global impact. They affect many aspects of life, including the global economy, travel, tourism, and education.

Armed with new technology, biologists work closely with public health and other health-care professionals to prevent dangerous pandemics. When a new disease-causing agent emerges, biologists study its evolutionary relationships to known pathogens. For example, investigators have determined that the 1918 flu pandemic was caused by an influenza A (H1N1) virus that may have mutated and newly emerged from a swine or avian host. The H1N1 strain that was identified in 2009 was related to the 1918 pathogen.

Biologists determined that the 2009 H1N1 strain evolved from a combination of viruses that infected swine, birds, and humans. They found that this strain of H1N1 contains unique combinations of gene segments for which humans do not have preexisting immunity. Knowledge about a

virus's origins provides important clues to its structure and behavior, and suggests hypotheses for combating it. Scientists must then test their hypotheses in the laboratory. Researchers were able to determine the antigens (proteins) on the surface of H1N1. These antigens must combine with receptors on human cells in order to infect the cells. Based on careful studies of H1N1, a vaccine was quickly developed.

Pathogens can strike quickly and spread rapidly, and the continuous evolution of drug-resistant pathogens presents a major challenge. New varieties of H1N1 continue to emerge, and investigators must quickly characterize them and assess their potential virulence. Scientists predict that new varieties may show increased drug resistance and may be more virulent. In addition, recently developed vaccines may no longer be effective. Emerging diseases will be discussed further in Chapter 24.

This is an exciting time to study **biology,** the science of life. The remarkable new discoveries biologists are making almost daily affect every aspect of our lives, including our health, food, safety, relationships with humans and other organisms, and the environment of our planet. New knowledge provides new insights into the human species and the millions of other organisms with which we share this planet. Biology affects our personal, governmental, and societal decisions. For example, a combined effort at every level is necessary to provide the resources and knowledge to meet the challenges of global pandemics.

Whatever your college major or career goals, knowledge of biological concepts is a vital tool for understanding our world and for meeting many of the personal, societal, and global challenges that confront us. Among these challenges are the expanding human population, decreasing biological diversity, diminishing natural resources, global climate change, and prevention and cure of diseases, such as heart disease, cancer, diabetes, Alzheimer's disease, acquired immunodeficiency syndrome (AIDS), and influenza. Meeting these challenges will require the combined efforts of biologists and other scientists, health professionals, educators, politicians, and biologically informed citizens.

This book is a starting point for your exploration of biology. It will provide you with the basic knowledge and the tools to become a part of this fascinating science, as well as a more informed member of society.

1.1 THREE BASIC THEMES

LEARNING OBJECTIVE

1 Describe three basic themes of biology.

In this first chapter we introduce three basic themes of biology. These themes are interconnected with one another and with almost every concept that we discuss in this book.

1. **Evolution.** Populations of organisms have evolved through time from earlier forms of life. Scientists have accumulated a wealth of evidence showing that the diverse life-forms on this planet are related and that populations have *evolved,* that is, have changed over time, from earlier forms of life. The process of *evolution* is the framework for the science of biology and is a major theme of this book.
2. **Information transfer.** Information must be transmitted within organisms and among organisms, and organisms must be able to receive information from their environment. The survival and function of every cell and every organism depend on the orderly transmission of information. Evolution depends on the transmission of genetic information from one generation to another.
3. **Energy transfer.** All life processes, including thousands of chemical transactions that maintain life's organization, require a continuous input of energy. Most of the energy for life comes from sunlight. Energy from the sun is transferred through living systems from producers to consumers; decomposers obtain energy as they feed on the dead bodies and wastes of both producers and consumers. Energy is also continuously transferred from one chemical compound to another within every cell.

Evolution, information transfer, and energy transfer are forces that give life its unique characteristics. We begin our study of biology by developing a more precise understanding of the fundamental characteristics of living systems.

Review

- Why are evolution, information transfer, and energy transfer considered basic to life?
- What does the term *evolution* mean as applied to populations of organisms?

1.2 CHARACTERISTICS OF LIFE

LEARNING OBJECTIVE

2 Distinguish between living and nonliving things by describing the features that characterize living organisms.

We easily recognize that a pine tree, a butterfly, and a horse are living things, whereas a rock is not. Despite their diversity, the organisms that inhabit our planet share a common set of characteristics that distinguish them from nonliving things. These features include a precise kind of organization, growth and development, self-regulated metabolism, the ability to respond to stimuli, reproduction, and adaptation to environmental change.

Organisms are composed of cells

Although they vary greatly in size and appearance, all organisms consist of basic units called **cells.** New cells are formed only by the division of previously existing cells. As will be discussed in Chapter 4, these concepts are expressed in the **cell theory,** a fundamental unifying concept of biology.