Chapter 1

EXPLORING LIFE AND SCIENCE

# LEARNING OUTCOMES

## **1.1 The Characteristics of Life**

1. Explain the basic characteristics that are common to all living things.

2. Describe the levels of organization of life.

3. Summarize how the terms *homeostasis*, *metabolism*, *development*, and *adaptation* all relate to living organisms.

4. Explain why the study of evolution is important in understanding life.

## **1.2 Humans Are Related to Other Animals**

1. Summarize the place of humans in the overall classification of living organisms.

2. Describe the relationship between humans and the biosphere, and the role of culture in shaping that relationship.

**1.3 Science as a Process**

1. Describe the general process of the scientific method.

2. Distinguish between a control group and an experimental group in a scientific test.

3. Recognize the importance of scientific journals in the reporting of scientific information.

**1.4 Making Sense of a Scientific Study**

1. Explain the difference between anecdotal and testimonial data.

2. Interpret information that is presented in a scientific graph.

3. Recognize the importance of statistical analysis to the study of science.

**1.5 Challenges Facing Science**

1. Distinguish between science and technology.

2. Summarize some of the major challenges facing science.

# EXTENDED LECTURE OUTLINE

## **1.1 The Characteristics of Life**

The science of biology is the study of living organisms and their environments. All living things share certain characteristics of life.

**Life is Organized**

Atoms join together to form molecules that make up cells. A cell is the smallest structural and functional unit of an organism. In more complex living things, cells join to form tissues, which form organs, which form organ systems, which then form individual organisms. Biological organization extends beyond the individual to populations, communities, ecosystems, and finally the biosphere.

**Organisms Acquire Materials and Energy**

Human beings require an outside source of materials and energy to carry on life’s activities. Humans and other animals get these materials when they eat food. The ultimate source of energy for the majority of life on Earth is the sun.

**Organisms Maintain Homeostasis**

The ability of a cell or an organism to maintain an internal environment that operates under specific conditions is called homeostasis.

**Organisms Respond to Stimuli**

Living things respond to external stimuli, often by moving toward or away from a stimulus.

**Organsims Reproduce and Grow**

When organisms reproduce, they pass on genetic information to the next generation. Following fertilization of the egg by the sperm cell, the zygote that results undergoes growth and development. Growth is an increase in size and number of cells and is a part of development. In humans, development includes all the changes that occur from the time the egg is fertilized until death, as well as repair that takes place following an injury. DNA enables living organisms to pass on hereditary information from parent to child.

**Organisms Have an Evolutionary History**

Evolution is the process by which a population changes through time. Evolution explains both the unity and the diversity of life.

## **1.2 Humans Are Related to Other Animals**

Living things are now classified into three domains: Archaea, Bacteria, and Eukarya. Humans are mammals within the vertebrates of the kingdom Animalia within the domain Eukarya.

## **Humans Have a Cultural Heritage**

Culture encompasses human activities and products that are passed on from one generation to the next outside of direct biological inheritance. This includes beliefs, values, and skills.

## **Humans Are Members of the Biosphere**

All living things on Earth are part of the biosphere, a living network that spans the surface of the Earth into the atmosphere and down into the soil and seas.

**1.3 Science as a Process**

Science is a way of knowing about the natural world.

**The Scientific Method Has Steps**

The process of science involves the scientific method, which includes observation, hypotheses, controlled experiments, conclusions that either support or reject hypotheses, and reformulation of hypotheses.

**Start with an Observation**

The scientific method begins with observation. Scientists may expand their understanding beyond observations by taking advantage of the knowledge and experiences of other scientists.

**Develop a Hypothesis**

After making observations and gathering knowledge about a phenomenon, a scientist uses inductive reasoning. A hypothesis is a supposition that is formulated after making an observation. A hypothesis is based on existing knowledge, so it is much more informed than a mere guess. It can be tested by obtaining more data, often by experimentation.

**Make a Prediction and Perform Experiments**

An experiment is an artificial situation devised to test a hypothesis. The manner is which a scientist intends to conduct an experiment is called the experimental design. If the hypothesis is well prepared, then the scientist should be able to make a prediction of what the results of the experiment will be. Experiments can take many forms, however in all experimental designs, the researcher attempts to keep all the conditions constant except for the experimental variable. One or more test groups are exposed to the experimental variable, but one other group called the control group, is not. Scientists often use model organisms and model systems to test a hypothesis.

**Collect and Analyze the Data**

Statistical analysis allows a scientist to detect relationships in the data that may not be obvious on the surface.

**Develop a Conclusion**

Scientists must analyze the data in order to reach a conclusion about whether a hypothesis is supported or not. In science, many experiments, often involving a considerable number of subjects, are required before a conclusion can be reached.

**Scientific Theory**

The ultimate goal of science is to understand the natural world in terms of scientific theories such as the cell theory and the theory of evolution. These concepts are based on the conclusion of a large number of observations and experiments. Evolution is the unifying concept of biology because it makes sense of what we know about the nature of life.

**An Example of a Controlled Study**

Controlled laboratory studies involve two groups of subjects, a control group not given the test medication or treatment, and the test group given the medication or treatment. It is important to reduce the number of possible differences between the two groups.

**The Results**

A double-blind study helped researchers determine if medications could relieve stomach

ulcers.

**Publication of Scientific Studies**

The results of scientific studies are published in a scientific journal so that an

experiment’s design and results can be available to all scientists.

**Further Study**

The conclusion of one experiment often leads to another experiment.

**Scientific Journals Versus Other Sources of Information**

The information in many scientific journals is highly regarded by scientists because of the review process. Unfortunately, the studies in scientific journals may be technical and difficult for a layperson to read and understand.

**1.4 Making Sense of a Scientific Study**

When evaluating scientific information, it is important to consider the type of data given to support it. Anecdotal data and correlations are not considered reliable data.

**What to Look For**

It is important to read beyond the abstract (synopsis) at the beginning of the study. Always examine the investigators’ methodology and results before going to the conclusion. Keep in mind that the conclusion is an interpretation of the data.

**Graphs**

Data are often depicted in the form of a bar graph or a line graph. A graph shows the relationship between two quantities with the experimental variable plotted along the horizontal or x-axis, and the result plotted along the vertical or y-axis.

**Statistical Data**

Most authors who publish research articles use statistics to help them evaluate experimental data. In statistics, the standard error tells us how uncertain a particular value is.

**Statistical Significance**

When scientists conduct an experiment, there is always the possibility that the results are due to chance or some other factor other than the experimental variable. This is taken into account when they calculate the probability value that their results were due to chance alone.

**1.5 Challenges Facing Science**

Science is a systematic way of acquiring knowledge about the natural world. It can only examine things that can be observed objectively, not supernatural or religious beliefs. Science differs from technology. Technology is the application of scientific knowledge to the interests of humans. Science and technology are not risk free.

**Bioethics**

Although science has improved our lives, science can produce potentially disastrous technologies. Technology raises difficult ethical issues.

**Human Influence on Ecosystems**

Human activities tend to modify ecosystems. Unfortunately, these technology-enabled human activities present a major threat to biodiversity. It is estimated that these activities have increased the extinction rate by a factor of 100 to 1000.

**Emerging Diseases**

New diseases have generated a lot of publicity. These *emerging diseases* may result from human behavior and use of technology.

**Climate Change**

Climate change is primarily due to an imbalance in the chemical cycling of the element carbon. However, due to human activities, more carbon dioxide is being released into the atmosphere than is being removed. This phenomenon is causing a rise in temperature called global warming.

# STUDENT ACTIVITIES

**Is It Alive?**

1. Bring to class a collection of living things and inanimate objects. Plastic models of living organisms are particularly useful. Have students gather around the specimens and identify the features that distinguish the living specimens from the inanimate ones. List the distinguishing features on the board or overhead as students suggest them.

**Humans Are Related to Other Animals**

2. Give students a list of organisms that include members of the four kingdoms within Eukarya (animals, plants, fungi, and protists). Ask them to divide the organisms into the various groups based on what they already know about these organisms. Then ask them to describe the common characteristics of each group.

**Exploring the Scientific Method**

3. Propose a simple hypothetical experiment in class, such as how salt affects the hatching of brine shrimp. Suggest the use of water, weak salt solution, and strong salt solution as the 3 “habitats.” Have students formulate a hypothesis and discuss the steps needed to carry out their plan. Have some brine shrimp, or photographs of brine shrimp, available for observation.

**Animals in the Lab**

4. Arrange to take your students to a laboratory on campus or at a nearby research facility to tour the animal housing facilities. Have the laboratory technician in charge of the lab explain what methods are used to ensure the animals receive good care and adequate housing. Explain the nature of the research involving animals in the research lab. Allow time for the students to ask questions.

**One Application of the Scientific Method**

5. Invite a fellow faculty member engaged in research on your campus to tell the class how they use the scientific method to address a specific question. Ask them to include a description of the control group(s) used in their research.

**CLASSROOM DISCUSSION TOPICS**

1. Viruses are not considered to be living organisms. Have students determine which of the characteristics of life viruses do not possess. Why would another parasitic organism, such as a disease-causing bacteria, be considered a living organism?

2. How does evolution explain both the unity and the diversity of life? Have students discuss what living things have in common and why this suggests a common ancestor. Have students discuss how living things are diverse and how this came about.

3. If humans are members of the biosphere, what gives them the right to modify and/or destroy the habitats of other organisms? Are humans “above” other organisms? Are they in some way “special” or “different”? What responsibilities do humans have to take care of the other organisms of the biosphere?

4. Read BIOLOGY MATTERS-Science “Adapting to Life at High Elevations” on page 6 of the text. Have students answer the following questions: What is the function of hemoglobin? How is the hemoglobin of people who live at high elevations different from the that of people who live at low elevations? How is the gene *EPSA1* and the transcription factor it encodesinvolved with hemoglobin production? Define the term “adaptation” using the example of Tibetans who reside at high altitudes.

5. Read BIOLOGY MATTERS-Science “Discovering the Cause of Ulcers” on page 13 of the text. Have students explain how Marshall’s approach was similar to, and different from, the scientific method.