

## Introduction: The Scientific Study of Life

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### Objectives

**Introduction** Explain how the lives of gray-headed flying foxes are closely interrelated to the life cycle of eucalyptus trees.

### The Scope of Biology

- 1.1 List the levels of organization from atom to ecosystem and note how the levels relate to each other.

### The Process of Science

- 1.2 Describe the goals and limits of scientific investigations.
- 1.2 Define a hypothesis and compare inductive and deductive reasoning.  
Explain how each of these are used in discovery science and hypothesis-driven science.
- 1.3 Describe the fly mimicry experiment from the text, noting the logical steps of the experimental process.

### Evolution, Unity, and Diversity

- 1.4 Describe and distinguish between the three domains of life. List examples of each domain.
- 1.5 Explain what provides the variety and common themes of life.
- 1.5 Describe seven properties that are common to all life.
- 1.6 Describe the process of natural selection. Explain why individuals cannot evolve.
- 1.7 Explain how the web of relationships gives an ecosystem its structure.
- 1.7 Compare the flow of chemical nutrients and the flow of energy in an ecosystem.

### Biology and Everyday Life

- 1.8 Explain why an understanding of biology is essential to all of our lives.

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### Key Terms

biology  
ecosystem  
community  
population  
organism  
organ system  
organ  
tissue

cell  
molecule  
hypothesis  
controlled experiment  
species  
domain  
kingdom  
Bacteria

Archaea  
Eukarya  
theory  
natural selection  
adaptation  
technology

## Lecture Outline

### Introduction *Life in the Trees*

- A. Self-introduction.
- B. Administrative details.
- C. Introduction to class content and course organization.
- D. Introductory comments about the science of biology.
- E. Core themes in biology.
  - 1. Biology is a broad collection of subdisciplines. How do biologists organize their subject matter?
  - 2. Can we uncover some common concepts that underlie all biological study?  
*NOTE:* As a preface to your review of the themes and characteristics of life, ask your students what they hope to get from the course, how the material to be covered in the course is relevant to their lives.
- F. To begin, we start our look at biology by focusing on the relationship between a gray-headed flying fox and the eucalyptus forest of southeast Australia.

## I. The Scope of Biology

### Module 1.1 Life's levels of organization define the scope of biology.

- A. The levels at which life is organized are (from most to least inclusive): **ecosystem, community, population, organism, organ system, organ, tissue, cell, molecule** (Figure 1.1).  
*NOTE:* Ask your students for examples, other than those in Figure 1.1, of each. Distinguish between unicellular and multicellular organisms. You may want to mention that there is another level between the cell and molecules (organelles; an example of an organelle is the nucleus of a cell). This concept is presented in Chapter 4.
- B. These levels represent a hierarchy because each level is built of parts at successively lower levels of organization.
- C. Researchers tend to focus individual studies on one or two levels. Later, the results can be organized along with other results into a broader picture of higher levels.  
*Preview:* The dynamics of higher levels of organization are discussed in Chapters 35 (populations) and 36 (communities and ecosystems).

## II. The Process of Science

### Module 1.2 Scientists use two main approaches to learn about nature.

- A. Discovery science: the process of gathering data by verifiable observations and measurements to explain natural phenomena. Baby bats cling to their mother in flight or the sequence of human DNA are mere observations.
- B. Hypothesis-driven science: conclusions drawn from the observations taken during "discovery science" lead the inquisitive scientist to ask more questions. Why do the baby bats cling to their mother in flight, or what is the function of the DNA sequence?
- C. What is a **hypothesis**? A tentative or educated guess to a problem or question that is being asked.

**Module 1.3** With the scientific method, we pose and test hypotheses.

A. The six steps of the scientific method are listed below with a brief explanation of each step.

1. Observations—from others or results of earlier tests.
2. Questions—about unclear aspects of the observations: How? Why? When?
3. Hypotheses—tentative explanations of a phenomenon phrased in such a way as to be testable.
4. Predictions—logical, testable outcomes of the hypotheses developed by the use of deductive reasoning. Predictions take the form of if (statement of hypothesis) is true, then (predictions).
5. Tests—to determine if the predictions are supported (fail to falsify) or falsified.  
*NOTE:* The process of science works not by proving but by disproving.
6. Results—used as evidence to support or falsify the hypotheses and usually become new observations in another cycle of investigation.

*NOTE:* Use of the process of science is a common underlying theme in biology research.

*Preview:* In addition to Module 1.3, other good examples of the application of the process of science to a problem can be found in, but are not limited to, Modules 35.7 (evolution shapes life histories), 36.18 (studies at Hubbard Brook), and 37.1 (Tinbergen's studies of digger wasp nesting behavior).

B. Case studies illustrate the scientific process.

1. The flashlight is a common household item that can be used to clearly demonstrate the scientific process. "How do you figure out how to fix it?"
2. The biologic case study of the snowberry fly demonstrates the use of the scientific method and answers the question regarding the wing markings and the waving behavior of the fly.
3. Experiments require a control to provide a basis of comparison and must be repeatable.
4. Science is an adaptable process and is tentative.

*NOTE:* Repeated observation and experimentation may result in a challenge to a hypothesis. Such challenges may be successful; thus, science is self-correcting.

5. Science does not deal with hypotheses that are not testable (i.e., questions that are not concerned with the natural world, such as the existence of ghosts).

**III. Evolution, Unity, and Diversity****Module 1.4** The diversity of life can be arranged into three domains.

- A. Making sense of the diverse life forms in the world, or even in a complex environment such as a tropical rain forest, can be overwhelming. To organize and simplify the process, we need a system for categorizing these living things.
- B. The three-domain system of classification enables biologists to group organisms using classical and molecular taxonomy (structure and function, and DNA and RNA sequence analysis).
- C. The three **domains** can be divided into two groups: cells without a nucleus (prokaryotes) and cells with a nucleus (eukaryotes).

*Preview:* The differences between prokaryotes and eukaryotes are discussed in greater detail in Chapter 4.

- D. Domain **Bacteria** (aka Eubacteria or true bacteria): unicellular prokaryotes that lack a nucleus; most bacteria are in this domain.
- E. Domain **Archaea** (Archaeobacteria): unicellular prokaryotes. Includes methanogens and extreme thermophiles. As will be discussed in Chapter 16, this domain has characteristics of both Eukarya and Bacteria.  
*Preview:* Differences between the Bacteria and Archaea are highlighted in Module 16.8.
- F. Domain **Eukarya**: unicellular and multicellular eukaryotes. Includes Kingdom Plantae (multicellular photosynthetic autotrophs), Kingdom Fungi (decomposers: molds, yeast, and mushrooms), and Kingdom Animalia (multicellular heterotrophs; cells without a cell wall). It is likely that the protists (a diverse group of microscopic single-celled and multicellular organisms, for example, algae and amoebae) comprise several kingdoms.  
*Preview:* The three-domain system is discussed further in Module 15.14.

**Module 1.5** Unity in diversity: All forms of life have common features.

- A. Life is diverse, but there are common themes that all living things exhibit.  
*Preview:* When viewed under a microscope, all cells look very similar (Chapter 4).
- B. Cells of all species contain many of the same molecules. For example, all cells have DNA, and the genetic information in DNA is coded in the same way in all cells. Variation in the nucleotide sequence allows for vast diversity within and between species.  
*Preview:* DNA is composed of nucleotides that contain the genetic information of all cells (Chapter 3, Module 3.20).
- C. The information in DNA provides the information for the properties that distinguish life from nonlife: order, regulation, growth and development, energy utilization, response to the environment, reproduction, and evolution.
- D. You might want to focus on one group of organisms to emphasize the point that, at each level of biological organization, there is similarity and diversity. For example: have the students describe the characteristics of a bird and then ask them to name as many birds as they can.

**Module 1.6** Evolution explains the unity and diversity of life.

*Preview:* This module previews Unit III, especially Chapter 13.

- A. **Theories** are much broader in scope than hypotheses and have much greater explanatory power.
- B. Darwin showed that the theory of evolution could explain the diversity of life and underlying commonalities of life's diversity.
- C. The theory of **natural selection**, as proposed by Charles Darwin, is an important mechanism by which evolution proceeds. Certain heritable characteristics are favored over others when subjected to environmental pressures. Yellow beetles are eaten in favor of dull beetles by the bird, removing them from the beetle population before they can reproduce.
- D. In particular, evolution explains why organisms are adapted to their environments. A pangolin is a particularly good example of an animal with many visible **adaptations** to a particular environment (Figure 1.6C).

**Module 1.7** Living organisms and their environments form interconnecting webs.

- A. Living things do not exist in isolation from their environment. An organism's environment includes both living and nonliving components.

- B. Plants, as well as certain prokaryotes and protists, use carbon dioxide, water, and the energy of sunlight to make food for themselves and heterotrophs by the process of photosynthesis.

*Preview:* The process of photosynthesis is discussed in detail in Chapter 7.

- C. All animals are ultimately dependent upon autotrophs (e.g., plants) for food.
- D. Decomposers (such as prokaryotes, fungi, and small animals) of dead organisms are important for the recycling of complex dead organic matter into mineral nutrients that plants can use.

*Preview:* Nutrient cycles can be divided into separate chemical or molecular cycles. Nutrient cycles are discussed in Chapter 36, Modules 36.14 through 36.17, and are important for understanding ecosystems.

- E. Relationships among the living and nonliving components of an ecosystem are illustrated as a web in Figure 1.7A and as energy flow and nutrient cycles in Figure 1.7C.
- NOTE:* Point out that these figures greatly simplify the many complex interactions among organisms and their environment and that the arrows represent the direction of flow of energy and nutrients.

*Preview:* This material previews the discussion of trophic levels and webs found in Chapter 36, Modules 36.9 and 36.10.

#### IV. Biology and Everyday Life

**Module 1.8** Connection: Biology is connected to our lives in many ways.

- A. Birth and death; human population; nutrition, exercise, and dieting; medical concerns of all kinds; agriculture, including forestry; biodiversity and endangered species; pollution and environmental changes due to global warming.

*Preview:* These environmental concerns are discussed in more detail in Chapter 38.

- B. **Technology** is the practical application of scientific knowledge and discovery.

### Class Activities

1. Illustrate how the process of science is applied in everyday life, even if only on a subconscious level. For example, ask the students what they do if, when they flip a light switch, the light does not go on, or what they do if their car will not start. Have them relate their activities to the process of science.
2. Divide the class into small groups. Have each group choose an organism and then decide which adaptations make it uniquely suitable for surviving in the habitat in which it is found. (For example, some dogs tend to bark quite a bit. Why? How is this an adaptation for surviving in the dog environment?) Have them explain how each of these adaptations is an anatomical/physiological solution to a particular environmental challenge. Because evolution is bound by historical constraints, for each of these adaptations, ask each group if they can think of a more efficient/elegant anatomical/physiological solution to the environmental challenge.
3. In small lecture or discussion sections, have students bring in current newspaper clippings on what they perceive to be a biological issue. (Virtually every newspaper every day will have something on medicine, ecology, biodiversity, pollution, nutrition, and countless other biological topics.) During lecture, have the class categorize each article according to its scientific validity. Have the students consider questions such as: the type of scientific approach that each article reports on—is it discovery science? hypothesis-driven science? Is the sample size of the study/studies mentioned? Is the sponsor of the science mentioned—e.g., did a company sponsor a study that concludes that its product does something wonderful? What could students do if they wanted to find out more about the topic? Where could they find scientifically valid information?

## Transparency Acetates

Figure 1.1	Life's hierarchy of organization
Figure 1.3A	The hypothesis-driven scientific method (Layer 1)
Figure 1.3A	The hypothesis-driven scientific method (Layer 2)
Figure 1.3A	The hypothesis-driven scientific method (Layer 3)
Figure 1.3B	Test: Replacing the batteries in the flashlight
Figure 1.3D	Test of the spider mimic hypothesis: masked wing markings
Figure 1.3E	Another test of the spider mimic hypothesis: wing transplants
Figure 1.6B	Natural selection
Figure 1.6C	Adaptations to the environment
Figure 1.7A	A web of interactions in a rain forest ecosystem
Figure 1.7C	Nutrient cycling and energy flow in an ecosystem

## Media

See the beginning of this book for a complete description of all media available for instructors and students. Animations and videos are available in the Campbell Image Presentation Library. Media Activities and Thinking as a Scientist investigations are available on the student CD-ROM and web site.

Animations and Videos	File Name
Sea Horse Video	01-06B-SeaHorsesVideo-B.mov
Sea Horse Video	01-06B-SeaHorsesVideo-S.mov

  

Activities and Thinking as a Scientist	Module Number
Web/CD Activity 1A: <i>The Levels of Life Card Game</i>	1.1
Web/CD Thinking as a Scientist: The Process of Science: <i>How Does Acid Precipitation Affect Trees?</i>	1.3
Web/CD Activity 1B: <i>Classification Schemes</i>	1.4
Web/CD Activity 1C: <i>DNA Molecules: Blueprints of Life</i>	1.5
Web/CD Activity 1D: <i>Evolution: Sea Horse Camouflage Video</i>	1.6
Web/CD Thinking as a Scientist: <i>How Do Environmental Changes Affect a Population?</i>	1.6