Biology Concepts and Investigations 4th Edition Hoefnagels Solutions Manual

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Hoefnagels - Biology: Concepts & Investigations

CHAPTER 1 – The Scientific Study of Life

WHERE DOES IT ALL FIT IN?

Chapter 1 introduces the fundamental principles that scientists use to understand the scope of biological knowledge. Stress to students that the concepts of evolution, life's organizational hierarchy, properties of living things, and scientific method are essential for understanding the other chapter topics covered throughout the semester. It may be fitting to refer to Chapter 1 when discussing the different levels of organismic complexity covered in the following chapters. The hierarchical levels of the organization of life provide a framework for the study of biology, which starts with the chemical composition of life, proceeds through the organization of cells, and continues to the structure of populations and biological communities. It is also important to stress to students that the information covered throughout the remaining chapters was derived from careful scientific inquiry using the principles of scientific method presented in this chapter. Students should regularly be reminded about how the information in this chapter relates to what is covered throughout the semester.

SYNOPSIS

This chapter provides students with two fundamental ideas needed to understand biology: 1. the modern scientific interpretation of life, and 2. the methodology used to create a scientific understanding of biological systems. A full appreciation of living properties cannot be formed unless students are asked to compare and contrast animate and inanimate entities. It is also important to assess how the major characteristics of living organisms explain the full diversity of life and differentiate live versus dead or diseased organisms. A very important principle to stress is that these living properties evolve with an organism to ensure survival from one generation to the next. The hierarchical organization of living organisms is introduced at this time to give a better understanding of organismic complexity and the roles of each level in the biosphere. Chapter 1 also uses taxonomy to show how biologists classify the biodiversity into rational categories that provide a better understanding of each organism.

An introduction to scientific methodology is critical for students to understand the process by which biological information is acquired and refined. This chapter presents the scientific method as a dynamic human process that involves peer review and statistical evaluation. The terminology about variables and

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experimental design is described in simple terms without compromising accuracy. It provides detailed examples of properly designed controlled experiments, which encourage hypothesis generation and conclusion formation. The chapter also stresses the importance of understanding the inherent limitations of carrying out scientific inquiry and the fact that science is a human endeavor and data may be subject to errors in interpretation.

The use of some lecture or recitation time to discuss the "Burning Questions" box, "w Now" box, and the end-of-chapter reading titled "Investigating Life: the Orchid and the Moth" is encouraged. The information in these three resources encourages students to use the chapter information in critical thinking situations.

LEARNING OUTCOMES

- 01.00.01 Describe how science is used to study life.
- 01.01.01 Describe the characteristics that all living organisms share.
- 01.01.02 Give examples of each level of biological organization.
- 01.02.01 Compare and contrast the three branches of life.
- 01.03.01 Apply the scientific method to design experiments and analyze data.
- 01.03.02 Identify the variables in an experiment.
- 01.03.03 Differentiate between hypotheses, theories, and facts.
- 01.03.04 List the limitations of the scientific method.
- 01.04.01 Explain how observations of orchids and moths confirmed a prediction of evolutionary theory.

COMMON STUDENT MISCONCEPTIONS

There is ample evidence in the educational literature that student misconceptions of information will inhibit the learning of concepts related to the misinformation. The following concepts covered in Chapter 1 are commonly misunderstood by students. This information on "bioliteracy" was collected from faculty and the science education literature.

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- Life is too complex to be explained with scientific reasoning.
- All organisms must have every characteristic of life.
- Inanimate objects cannot possess some of the characteristics of living organisms.
- Acquired characteristics can be inherited.
- All organisms have the same level of hierarchical organization.
- Most organisms on the Earth are either animals or plants.
- There is a single list of steps called "The Scientific Method."
- Hypotheses are merely a guess about natural phenomena.
- Theories are a scientist's opinion.
- Theories do not change over time.
- The control is not affected by variables.
- The use of scientific models is not accepted by much of the scientific community.
- Statistics are used to make data fit the hypothesis.
- The independent variable in an experiment is always controlled by the researcher.
- Evolution is a means of disproving the existence of a supernatural being.
- Biological principles can be described without evolutionary theory.
- Evolution only occurs on the individual organism level.
- Evolutionary adaptation occurs during the lifetime of an organism.
- The death of an individual organism can change the whole fate of the Earth.

INSTRUCTIONAL STRATEGY PRESENTATION ASSISTANCE

- 1. Use a simple activity as a tangible way of introducing the scientific method before a lecture on Chapter 1. The scientific method can be portrayed using a nonworking flashlight (have a nonfunctional bulb and dead batteries in it). Guide the class through the process of the scientific method needed to hypothesize and test what is needed to fix the flashlight. It is important to have working spare parts to get the flashlight working again.
- Many students devalue the scientific method when they see contradictory research studies in the news. Show the students some conflicting news articles related to everyday issues Biology: Concepts and Investigations, 4e

such as the health value of drinking wine or avoiding certain fats. This can then be used as a discussion point about the limitations of science and why certain studies of similar design may yield opposite conclusions.

3. Use projected images of various types of prokaryotic and eukaryotic organisms to demonstrate biodiversity. Then go to the World Wildlife Fund website to show students how various agencies study and protect global biodiversity.

HIGHER-LEVEL ASSESSMENT

Higher-level assessment measures a student's ability to use terms and concepts learned from the lecture and the textbook. A complete understanding of biology content provides students with the tools to synthesize new hypotheses and knowledge using the facts they have learned. The following table provides examples of assessing a student's ability to apply, analyze, synthesize, and evaluate information from Chapter 1.

Application	 Have students design an experiment to investigate the claim that soybean products in the diet of pregnant women may alter the development of children during fetal development. Have students apply the concept of homeostasis to explain the difference in characteristics between a living and a dead animal. Ask students to hypothesize an evolutionary explanation for the fact that some people have the genetic ability to control muscles to wiggle their ears.
Analysis	 Ask students to explain how the survival requirements of prokaryotes may differ from those of eukaryotic animals as a result of their level of hierarchical complexity. Ask students to select two of the most important criteria needed to determine if an unknown specimen collected from another planet is alive or not. Have the class analyze whether each characteristic of living organisms provided in Chapter 1 equally represents animals and plants.
Synthesis	 Ask students to describe how taxonomy would contribute to medical treatments used to control infectious diseases. Ask students to predict how a physician would treat a disease if the concept

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	 of scientific method were not developed. Have students explain how the release of a toxic pollutant into the oceans that kills one particular fish could affect each level of hierarchy associated with a lake in which the fish lives.
Evaluation	 Ask students to discuss implications of a disease caused by a purported organism that does not seem to possess any of the characteristics of life discussed in the chapter. Ask students to come up with some strategies to reduce the number of factors that limit the accuracy of scientific experimentation. Have students evaluate the pros and cons of using computer models as a substitute for experimentation in gaining an understanding of human diseases.

BIOETHICAL CONSIDERATION

Biological knowledge contributes to the betterment of human society in many ways. However, there are also various ethical concerns that are raised by the applications of this knowledge. Scientific explanations of living processes often conflict with religious views about the nature of life. Many societies end up having to balance the influx of scientific information with explanations and rules founded on religious principles. Facilitate a classroom discussion on the ethical considerations regarding the relationship between scientific thinking and religion.

FUN FACTS

Trivial facts about biology are a fun way to spice up a lecture. They can be read in class or placed at appropriate points in a lecture using the board or a projected presentation. The trivia can be used as a jumping point for students to further investigate the fact.

- The first scientific journals were the French *Journal des Sçavans* and the British *Philosophical Transactions*. Both journals were published in 1665.
- French scientist Antoine-Laurent de Lavoisier supposedly carried out his last experiment by deciding to blink as many times as possible after he was beheaded in the French Revolution. It is Biology: Concepts and Investigations, 4e

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said that his assistant counted 15 to 20 blinks while watching the beheading.

- An early notion of the emergence life, called abiogenesis or spontaneous generation, was promoted by Aristotle and led people to believe that snakes formed from horse hairs standing in stagnant water, mice developed from old cheese and bread wrapped in rags, and maggots were born from decaying meat.
- Early scientists followed a doctrine called "vitalism" that states that the processes of life are not entirely due to the laws of chemistry and physics alone, and that life is partially a self-determining vital force.
- Early vitalism proponents believed that the vital force of all living things was composed of four humors or liquids called black bile, blood, phlegm, and yellow bile.
- Linnaeus's hierarchical classification and binomial nomenclature of organisms has remained a standard model of taxonomy for over 200 years.

IN-CLASS CONCEPTUAL DEMONSTRATION

Brine shrimp provide a simple living model for investigating some of the properties of organisms. They are simple to view under a microscope and can be clearly projected on a screen using 100X magnification with a wet mount specimen. This activity demonstrates some of the characteristics of life covered in Chapter 1.

Materials

- Small container of large brine shrimp
- 1 microscope slide
- 1 small dropper
- 1 small dropper bottle of trypan blue (dissolve 0.2 g trypan blue in 100 ml distilled)
- 1 projector microscope or microscope attached to a video projector
- 1 small bottle of cold water with a dropper
- 1 small bottle of 50°C water with a dropper
- 1 small bottle of room temperature 3% hydrogen peroxide with a dropper
- 1 small bottle of brewed dark coffee

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• 1 small bottle of room temperature pure methanol with a dropper

Procedure & Inquiry

- 1. Place 3 or 4 brine shrimp on a slide. Use just enough water to keep the shrimp immobilized, but submerged in water.
- 2. Place the slide under the microscope and focus the image using 100X magnification so that a whole brine shrimp can be seen clearly.
- 3. Ask the students which properties of life and levels of organization are exhibited by the brine shrimp.
- 4. Add the 50°C water to the slide and ask the students to observe what happens. After awhile the shrimp should move faster. Then ask the students what properties of life the exercise demonstrates. (Some may answer metabolism, movement, or response to stimuli.)
- 5. Add one drop of 3% hydrogen peroxide to the slide and ask the students to observe what happens. They should see bubbling due to catalase activity from bacteria on the surface of the shrimp. Then ask the students what properties of life the exercise demonstrates. (Some may answer metabolism or response to stimuli.)
- 6. Add one drop of strong brewed coffee to the slide and ask the students to observe what happens. Again, ask them to observe and explain. They should see the shrimp speed up kicking activity.
- 7. Then add the trypan blue to the slide. Let the students observe the shrimp as you add 3 drops of the methanol. The students should observe some of the cells turning blue as the shrimp cells eventually die outside of the internal environment of the body. Have them make hypotheses about this last observation.

QUICK LABORATORY IDEA

Natural Selection

This laboratory activity has students hypothesizing about the possible survival value of particular human tastes. (Caution: this lab involves the tasting of substances in class.)

1. Provide students with the following materials:

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- a. PTC (phenylthiocarbamide) taste paper
- b. Sodium benzoate taste paper
- c. Thiourea taste paper
- d. Clean fresh cabbage
- e. Jar of honey
- f. Strong coffee
- g. Toothpicks for tasting samples
- h. Clean disposable spoons for tasting honey and coffee
- i. Access to the Internet
- 2. Explain to the class that they will be testing themselves for the presence of certain taste buds based on how the tongue responds to certain molecules.
- 3. Ask students to determine the number of people in class who can and cannot taste the PTC, sodium benzoate, and thiourea taste papers.
- 4. Then ask them to see if the ability to taste or not taste a particular paper is related to a person's like or dislike of the taste of cabbage, coffee, or honey.
- 5. Let the class know that certain genes determine the ability to taste PTC, sodium benzoate, and thiourea. Then have the students research online to find evidence that the ability to taste these compounds is associated with people from particular regions of the world.

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LEARNING THROUGH SERVICE

Service learning is a strategy of teaching, learning, and reflective assessment that merges the academic curriculum with meaningful community service. As a teaching methodology, it falls under the category of experiential education. It is a way students can carry out volunteer projects in the community for public agencies, nonprofit agencies, civic groups, charitable organizations, and governmental organizations. It encourages critical thinking and reinforces many of the concepts learned in a course.

- 1. Have students give presentations about life's organizational hierarchy at an area nature center.
- 2. Have students visit a local elementary school to give a presentation on the properties of life.
- 3. Have students judge science fairs that focus on projects emphasizing the use of the scientific method.
- 4. Have students prepare a poster or display on biodiversity for an Earth Day program or another related event.

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