Instructor's Manual
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For
Biology 11e by Sylvia Mader

The Instructor's Manual

The *Instructor's Manual* is designed to help you coordinate the various ancillaries and aids that accompany *Biology.* The manual is aligned with the text. There is a chapter in the manual for each chapter in the text. Each chapter includes the following:

Learning Outcomes

The major goals of each section of the chapter are provided in the textbook and in this manual. All learning outcomes may be assessed using McGraw-Hill Connect® Biology activities.

The Chapter Outline

The concepts as presented in the text are outlined under each major heading in each chapter. The outline provides a basis for an organized lecture or discussion class, and the outline format is kept direct and concise to help students who have not developed good outlining skills to learn them. While it is critical that students meaningfully internalize distinct biology concepts, they must also organize this huge body of information. Note-taking in an organized manner is an important aspect of understanding the intellectual content of biology. An instructor who presents material in a clear and logically organized manner helps to set the student's understanding of the chapter concepts. The importance of organizing biology concepts by outline cannot be overstated.

Lecture Enrichment Ideas

Every chapter in this *Instructor's Manual* includes from 3–20 enrichment ideas. These provide ideas for discussions, techniques to relate the concepts to students meaningfully within their realm of experiences, suggested questioning strategies, and additional applications of the chapter concepts.

Critical Thinking Questions

Sample critical thinking questions are supplied for use in testing or to stimulate class discussion.

1 INTRODUCTION

CHAPTER 1 A VIEW OF LIFE

The text opens with a description of the characteristics of life, followed by a discussion of the human species' integration into the highly-diverse biosphere. Taxonomic classification, the system by which all organisms are categorized, is discussed. The steps of the scientific method are outlined. A scientific experiment is described in detail. The challenges facing science, includes new, topical sections on emerging diseases and ecosystems threatened with extinction.

Learning Outcomes

1.1 The Characteristics of Life

1. Distinguish between the levels of biological organization.
2. Identify the basic characteristics of life.

1.2 Evolution and the Classification of Life

1. Distinguish between the three domains of life.
2. Explain the relationship between the process of natural selection and evolutionary change.

1.3 The Process of Science

1. Identify the components of the scientific method.
2. Distinguish between a theory and a hypothesis.
3. Explain statistical analysis of data and statistical significance.
4. Review an example of the scientific method.

1.4 The Challenges Facing Science

1. Explain the difference between science and technology.
2. Recognize the importance of maintaining biodiversity.
3. Explain how extinction threatens biodiversity.
4. Describe how climate change and emerging diseases are challenges facing science.
5. Describe the contributions of the tropical rain forest and coral reef ecosystems to maintaining biodiversity.

Chapter Outline

1.1 How to Define Life

A. Living Things Are Organized
   1. Organization of living systems begins with atoms, which make up basic building blocks called

elements.

2. The **cell** is the basic structural and functional unit of all living things.
    a. **Unicellular** organisms are single-celled organisms that either live independently, or as colonies.
    b. **Multicellular** organisms are made up of many cells that work together.
3. Different cells combine to make up tissues (e.g., nerve tissue).
4. Tissues combine to make up an organ (e.g., the brain).
5. Specific organs work together as an organ system (e.g., the brain, spinal cord, etc.).
6. Multicellular organisms (each an "individual" within a particular species) contain organ systems.
7. A species in a particular area (e.g., gray squirrels in a forest) constitutes a population.
8. Interacting populations in a particular area comprise a community.
9. A community plus its physical environment is an ecosystem.
10. The biosphere is comprised of regions of the Earth's crust, waters, and atmosphere inhabited by organisms.
11. Each level of organization is more complex than the level preceding it.
12. Each level of organization has **emergent properties** due to interactions between the parts making up the whole; all emergent properties follow the laws of physics and chemistry.

B. Living Things Acquire Materials and Energy
1. Maintaining organization and conducting life-sustaining processes requires an outside source of **energy**, which is defined as the capacity to do "work."
2. **Metabolism** is all the chemical reactions that occur in a cell.
3. The ultimate source of energy for nearly all life on Earth is the sun; plants and certain other organisms convert solar energy into chemical energy by the process of **photosynthesis.**

C. Living Things Maintain Homeostasis
1. All organisms must maintain a state of biological balance, or **homeostasis**.
2. Temperature, moisture level, pH, etc. must be maintained within the tolerance range of the organism.
3. In order to maintain homeostasis, body systems monitor internal conditions and make adjustments when needed.
4. Organisms have intricate feedback and control mechanisms to maintain homeostatic balance.

D. Living Things Respond
1. Living things interact with the environment and with other living things.
2. Response often results in movement of the organism (e.g., a plant bending toward the sun to capture solar energy, a turtle withdrawing into its shell for safety, etc.).
3. Responses help ensure survival of the organism and allow the organism to carry out its biological activities.
4. The collective responses of an organism constitute the behavior of the organism.

E. Living Things Reproduce and Develop
1. **Reproduction** is the ability of every organism to give rise to another organism like itself.
2. Bacteria, protozoans, and other unicellular organisms can reproduce asexually by splitting in two (binary fission).
3. Multicellular organisms often reproduce sexually, uniting sperm and egg, each from a different individual, resulting in an immature individual that develops into the adult.
4. The instructions for an organism's organization and development are encoded in **genes**.
5. Genes are comprised of long molecules of DNA (deoxyribonucleic acid); DNA is the genetic code in all living things.
6. Genes are passed on from generation to generation. Methods to ensure genetic variability include random combination of sperm and egg and mutations.

F. Living Things Have Adaptations
1. **Adaptations** are modifications that make organisms better able to function in an environment.
2. **Evolution** includes the way in which populations change over the course of generations to become more suited to their environments.

1.2 Evolution, the Unifying Concept of Biology

A. Organizing Diversity

1. **Taxonomy** is the discipline of identifying and grouping organisms according to certain rules.
2. **Systematics** is the study of the evolutionary relationships between organisms.
3. Taxonomic classification changes as more is learned about living things, including the evolutionary relationships between species.
4. From smaller (least inclusive) categories to larger (more inclusive), the sequence of classification categories is**: species, genus, family, order, class, phylum, kingdom,** and **domain**.
5. The species within one genus share many specific characteristics and are the most closely related, while species in the same kingdom share only general characteristics with one another.
6. Biochemical evidence suggests that there are three domains: **Bacteria, Archaea,** and **Eukarya.**
7. The domains Bacteria and Archaea contain unicellular **prokaryotes**; organisms in the domain Eukarya are **eukaryotes** that have a membrane-bound nucleus.
8. The prokaryotes are structurally simple but are metabolically complex.
9. Archaea can live in water devoid of oxygen, and are able to survive harsh environmental conditions (temperatures, salinity, pH).
10. Bacteria are adapted to live almost anywhere (water, soil, atmosphere, in/on the human body, etc.).
11. The domains Archaea and Bacteria are not yet categorized into kingdoms.
12. Eukarya contains four kingdoms: Protista, Fungi, Plantae, and Animalia.
13. **Protists** (kingdom Protista) range from unicellular forms to multicellular forms.
14. **Plants** (kingdom Plantae) are multicellular photosynthetic organisms.
15. **Fungi** (kingdom Fungi) are the molds and mushrooms.
16. **Animals** (kingdom Animalia) are multicellular organisms that ingest and process their food.
17. **Binomial nomenclature** refers to a two-part scientific name: the genus (first word, capitalized) and the specific epithet of a species (second word, not capitalized).
18. Scientific names are based on Latin and are used universally by biologists.

B. Evolution is Common Decent with Modification

1. **Natural selection** is the process by which species become modified over time.
2. In natural selection, members of a species may inherit a genetic change that makes them better suited to a particular environment.
3. These members would be more likely to produce higher numbers of surviving offspring.

1.3 The Process of Science

1. Biology is the scientific study of life, and it consists of many disciplines.
2. The scientific process differs from other ways of learning in that science follows the **scientific method**, which is characterized by observation, development of a hypothesis, experimentation and data collection, and forming a conclusion.

A. Observation

1. Scientists believe nature is orderly and measurable, and that natural laws (e.g., gravity) do not change with time.
2. Natural events, called **phenomena,** can therefore be understood from **observation**.
3. Scientists also use the knowledge and experiences of other scientists to expand their understanding of phenomena.
4. Chance alone can sometimes help a scientist get an idea (e.g., Alexander Fleming's discovery of penicillin).

B.. Hypothesis

1. **Inductive reasoning** allows a person to combine isolated facts into a cohesive whole.
2. A scientist uses inductive reasoning to develop a possible explanation (a **hypothesis**) for a natural event; the scientist presents the hypothesis as an actual statement.
3. Scientists only consider hypotheses that can be tested (i.e., moral and religious beliefs may not be testable by the scientific method).

C. Experiments, Predictions, Observations, and Data

1. Testing a hypothesis involves either conducting an **experiment** which relies on a prediction of the experimental results, or making further observations.

2. **Deductive reasoning** involves “if, then” logic to make a **prediction** based on knowledge of the factors in the experiment.
3. An **experimental design** is the manner in which an experiment is conducted.
4. An experiment should include a **control group** which goes through all the steps of an experiment but lacks (or is not exposed to) the factor being tested and an experimental group (tested with the independent variable).
5. Scientists may use a **model** (a representation of an actual object) in their experiments.
6. Results are based on examination of the responding variable (dependent variable) obtained from use of the model.
7. **Data** are the results of an experiment, and are observable and objective rather than subjective.
8. Data are often displayed in a graph or table.
9. Results usually include a **standard deviation**, which is a statistical analysis that is a measure of how much the data in the experiment varies.
10. Many studies rely on statistical data which, among other things, determines the probability of error in the experiment.
11. Statistical significance means the experimental results were not due to chance or some factor other than the experimental (independent) variable.

D. Conclusion
1. Whether the data support or reject the hypothesis is the basis for the **conclusion.**
2. The conclusion of one experiment can lead to the hypothesis for another experiment.
3. Scientists report their findings in scientific journals so that their methodology and data are available to other scientists.
4. The experiments and observations must be repeatable or the research is suspect.

F. Scientific Theory
1. The ultimate goal is to understand the natural world in **scientific theories,** which are concepts that join supported, related hypotheses, and are supported by a broad range of observations, experiments, and data.
2. Some basic theories of biology are:
   a. Cell: all organisms are made of cells.
   b. Homeostasis: the internal environment of an organism stays relatively constant.
   c. Evolution: all living things have a common ancestor.
3. A **principle** or a **law** is a theory that is generally accepted by most scientists.

G. Using the Scientific Method
1. A controlled study ensures that the outcome is due to the experimental (independent) variable, the factor being tested.
2. The result is called the **responding (dependent) variable** because it is due to the independent variable.
3. The Experiment
   a. Hypothesis: Newly discovered antibiotic B is a better treatment for ulcers than antibiotic A, which is in current use.
   b. Prediction: Patients with ulcers who are matched by sex, age, weight, and other illnesses and treated with placebo (no treatment), antibiotic A or antibiotic B will show statistically significant responses to their treatments which will indicate that antibiotic B is a better treatment.
   c. Control group: Ulcer patients receive only placebo..
   d. Test groups: Ulcer patients receive either antibiotic A or antibiotic B.
   e. All other variables are equal.
   f. Results: After endoscopy, antibiotic two proved to be more effective. Thus, the hypothesis is **supported.**

1.4 Challenges Facing Science
1. Science differs from technology in that technology is the application of scientific knowledge to the interests of humans.

2. **Biodiversity and Habitat Loss**
   a. Biodiversity is the total number of species, the variability of their genes, and their ecosystems.
   b. **Extinction** is the death of a species or larger group; perhaps 400 species become extinct every day.
   c. Two biologically diverse ecosystems, tropical rain forests and coral reefs, are severely threatened by the human population.
   d. Destruction of healthy ecosystems has unintended effects including: loss of food, medicine, raw materials, and extinction of organisms.
   e. The continued existence of the human species is dependent on the preservation of ecosystems and the biosphere

3. **Emerging Diseases-** H5N1 and H7N9, SARS and Ebola have been in the news as new, or emerging diseases.
   a. Increased exposure to insect or animal populations or changes in human behaviors and use of technologies may have resulted in these new diseases.
4. **Climate Change-** Refers to changes in the normal cycles in the earth's climate that may be attributed to human activity.
   a. Normally carbon is cycled within an ecosystem; However, due to human activities more carbon is being released into the atmosphere than being removed.
   b. The increased amount of carbon dioxide and other gasses is causing global warming due to the greenhouse effect, which is causing significant changes to earth's ecosystems.

Lecture Enrichment Ideas

Experience Base: [*As teachers, we make assumptions about the common experiences shared with our students and thus the meaningfulness of the vocabulary we use. Questions that solicit student feedback establish if those experiences are adequate and the concepts are being understood. Students who relate their experiences and understanding in turn help classmates learn the concepts*.] Lecturers new to a college or university may wish to confer with veteran teachers about the state's high school biology and other science requirements, and the proportion of students likely to come from farm or urban backgrounds. Most high school biology textbooks address basic properties of life and the five kingdom system. Only the 1998 texts onward mention domains. Most entering college undergraduates do not have genuine experience with open-ended and purposeful science research.

1. Ask the students to think about how they may use the scientific method in everyday life.

2. Give the students a list of items, both life organisms and objects. Ask the students which items are living and why? Have them go through the characteristics of living things to determine their answers.

3. Discuss some current events that relate to how human populations are disrupting ecosystems. Perhaps have students look in newspapers to find relevant articles, or discuss some major events: Chernobyl, the BP oil spill in the Gulf of Mexico, or even clearing land for housing or commercial developments.

4. Provide pictures of organisms and have students group them based on taxonomic classification.

5. People from all backgrounds and educational levels make distinctions between living and non-living things. Even if they have not read the material in the text, students can be led through a common sense discussion of "what is life?" List the common traits of living things: growth, reproduction, response to the environment, metabolism, etc. Ask whether any one of these aspects alone distinguishes a living organism from a nonliving substance. Is it necessary, for example, that every individual within a species be able to reproduce? Select specific species from various kingdoms and describe some of the responses and some of the adaptations those species have. Discuss how those responses and adaptations allow those species to survive in their environment.

6. Scientists are attempting to confirm whether there is or ever has been life on Mars. What phenomena should they look for? What is required for us to know for sure that there is or was life on Mars?

7. Read job descriptions for biologists (e.g., biochemist, anatomist, population ecologist, etc.) available from current journals and newspapers and ask students what level of biological organization the scientist studies.

8. List organisms with which students should be familiar; ask them to place the organisms into the correct kingdom based on their known characteristics. List unfamiliar organisms and their characteristics; ask students to determine the kingdom to which they belong.

9. Discuss the evolutionary relatedness of mammals. Ask students to consider Australian marsupials that fit into the various niches filled by other mammals in other parts of the world. Note how marsupials are more closely related to one another but have diversified to fill many niches.

10. Discuss the theory that proposes that all life is a result of the development from unicellular ancestors with the same basic chemical structures and metabolism.

11. Discuss how organisms diversify due to the effects of mutation and selection by the environment.

12. Caution students not to confuse the terms "name," "identify," and "classify." "Classify" only involves grouping. Only a specialist who describes and publishes a new species "names" the species. In most cases, we are merely "identifying" organisms that are already known to science, originally "named" by taxonomists and "classified" by systematicists.

13. Ask students to design an experiment, following the scientific method, in which they test a weight loss drug. Ensure that the experiments have the proper controls, are conducted logically and realistically, that the data (made up by the instructor for the sake of this experiment) are interpreted correctly, and that a proper conclusion is drawn.

14. Ask students for examples of the scientific method in their everyday lives, such as preparing dinner, determining how to dress for the day's weather or activities, finding their way around a strange area, or dealing with a malfunctioning car.

15. Have students search a week's newspapers for examples of using the scientific method in the news—such as testing consumer goods or reports on medical research—and discuss them in class. Bring in a tabloid newspaper making fabulous claims and discuss why it does not fulfill scientific standards.

16. Discuss the difference between scientific observations of the natural world and superstitions such as those associated with Friday the thirteenth and black cats. Scientific examination of examples involving water dousing, spontaneous human combustion, crop circles, and other modern misbeliefs are given in the *Skeptic* and *Skeptical Inquirer* magazines.

17. Discuss why it is possible to prove a hypothesis or theory false but not to prove it absolutely true. (This Karl Popper concept of "falsifiability" has limited usage in science and is not applicable in all areas of biology. However, deep discussion of this concept is best left to upper level philosophy of science courses where the students will have had some actual direct experiences with genuine research.)

18. Ask students if they believe the world is spherical. Have them cite evidence to support their belief. However, unless they have flown in the Concorde, they have no direct observational evidence to prove that the Earth is in fact spherical. Emphasize the point that even though they have no direct, personal evidence that fits the spherical Earth model, science frequently relies on *reasoning* and *models* as well as observational data.

Critical Thinking

Question 1. Assume that you found an object that you think might be "alive." What would be several things you would need to observe about this object to determine if it was, in fact, alive?

Answer: You could subject the object to environmental stimuli (heat, pH changes, physical pressure, etc.) to see if it responded to any of those stimuli. The object should have a number of physical characteristics (adaptations) that allow it to survive in a particular environment. The object would have a metabolism. At the biochemical level, the object would have DNA and certain molecules in common with all known life on Earth. The object may or may not be able to reproduce: it could be a sterile individual of a species or it could be a sexually-reproducing organism, in which case a "mate" would be needed!

Question 2. Arguments about teaching evolution in the public school classroom continually attract public attention as elected school boards (in certain states) meet to approve new science teaching curricula. Issues raised in the public sector (not from scientists) include arguments about evolution being "just a theory," giving religious creationism "equal time," and replacing the definition of science as study of natural phenomena with science as a logical construct. Why do scientists reject these arguments?

Answer: Although school boards must vote on policy, scientists do not "vote" on science. The nature of "theory" in this context means considerably more than the street vernacular "it's just a theory." Science does not provide "equal time" to non-science explanations that do not lend themselves to observation, experimentation, and the development of new research. And, although many academic fields are based on "logic" (most notably mathematics), science is defined and uniquely tethered to concepts that are in agreement with the workings of the natural world. "Supernatural" explanations simply do not allow a researcher to formulate tests and expand understanding of the "natural world."

Question 3. Ecology experiments can be separated into two general categories. Some ecologists prefer to bring an organism into the laboratory and isolate it in a chamber where they can keep the setup simple and where they determine all the environmental conditions. Other ecologists prefer to study organisms in the wild and attempt to determine why they occur in certain natural habitats. Using terms for scientific methodology, explain the benefits of both systems.

Answer: The natural environment is so complex that only simple lab settings can eliminate complex factors and show how an organism responds to just one variable. A controlled chamber allows the scientist to set up a control group that lacks just the experimental variable. On the other hand, a natural environment is closer to what the organism actually encounters. There may be many factors in a natural environment that are major and important influences on an organism but which a researcher has not considered in a controlled lab setting experiment. While two "equal" field sites can be used, one as a treatment and one as a control, the ecologist cannot be certain that another uncontrolled factor in nature is not involved or that chance variation is not a contributing factor. Ecologists often integrate the results of both types of research to formulate their conclusions.

UNIT I THE CELL

Because the cell is the basic unit of life, cell structure, function, and metabolism are major concepts necessary to understand life. Cellular metabolism is simplified and cellular processes are described in preparation for an understanding of genetic control, the origin of the cell, and adaptation to the environment.