

Telecourse Student Guide

for

Cycles of Life

EXPLORING BIOLOGY

Third Edition

Gerald L. Kellogg



Brooks/Cole
Thomson Learning

Australia • Canada • Mexico • Singapore • Spain • United Kingdom • United States

Coast Community College District

William M. Vega, Chancellor

Leslie Purdy, President, Coastline Community College

Dan C. Jones, Administrative Dean, Office of Instructional Systems Development

Laurie R. Melby, Director of Production

Judy Garvey, Publications Supervisor

Wendy Sacket, Senior Publications Assistant

Thien Vu, Publications Assistant

COPYRIGHT © 2003 by Coast Community College District.

Distributed by: **Coast Learning Systems**

Coastline Community College
11460 Warner Avenue
Fountain Valley, CA 92708
Telephone: 800-547-4748
FAX: 714-241-6286
www.CoastLearning.org

Published by Wadsworth Group. Brooks/Cole is an imprint of the Wadsworth Group, a division of Thomson Learning.

The Thomson Learning logo is a trademark used herein under license.

For more information, contact Brooks/Cole, 511 Forest Lodge Road, Pacific Grove, CA 93950, or electronically at <http://www.brookscole.com>

All rights reserved. No part of this work covered by the copyright hereon may be reproduced, or used in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, Web distribution, information networks, or information storage and/or retrieval systems—without the written permission of the publisher.

For permission to use material from this work, contact Coast Learning Systems at (800) 547-4748.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-534-38567-2

Contents

<i>Preface</i>	v
Lesson 1: Biological Concepts	1
Lesson 2: Chemical Foundations	13
Lesson 3: Cell Structure and Function	25
Lesson 4: Metabolism	39
Lesson 5: Energy In—Energy Out.....	52
Lesson 6: Mitosis and Meiosis.....	64
Lesson 7: Patterns of Inheritance	75
Lesson 8: DNA Structure and Function	89
Lesson 9: Proteins	102
Lesson 10: Microevolution	115
Lesson 11: Macroevolution	128
Lesson 12: Viruses, Bacteria, and Protistans.....	141
Lesson 13: Fungi, Plants, and Animals	153
Lesson 14: Plants: Tissues, Nutrition, and Transport	167
Lesson 15: Plants: Reproduction and Development	180
Lesson 16: Animals: Structure and Movement.....	192
Lesson 17: Animals: Circulation	207
Lesson 18: Animals: Immunity.....	221
Lesson 19: Animals: Respiration	234
Lesson 20: Animals: Digestion and Fluid Balance	247
Lesson 21: Animals: The Neural Connection.....	262
Lesson 22: Animals: Endocrine Control	275
Lesson 23: Animals: Reproduction and Development.....	289
Lesson 24: Populations and Communities	302
Lesson 25: Ecosystems and the Biosphere	313
Lesson 26: The Human Factor.....	326
Answer Key	341

LESSON 3

Cell Structure and Function

Assignments

For the most effective study of this lesson, we suggest that you complete the following assignments in the sequence listed below:

Before Viewing the Video Program

- Read the Overview and Learning Objectives for this lesson. Use the Learning Objectives to guide your reading, viewing, and thinking.
- Read Chapter 4, “Cell Structure and Function,” pages 50–73, in the Starr textbook. Also read Chapter 5, “Ground Rules of Metabolism,” pages 80 and 86–89.

Or read, in the Starr/Taggart textbook, Chapter 4, “Cell Structure and Function,” pages 52–77, and Chapter 5, “A Closer Look at Cell Membranes,” pages 78–93.

- Read the Viewing Notes in this lesson.

View the “Secrets of the Cell” Video Program

After Viewing the Video Program

- Briefly note your answers to the questions at the end of the Viewing Notes.
- Review all reading assignments for this lesson, especially the Chapter 4 Summary on pages 71–72 in the Starr textbook (Chapter 4 and Chapter 5 Summaries on pages 75–76 and 92 respectively in the Starr/Taggart textbook) and the Viewing Notes in this lesson.
- Write brief answers to all the Review Questions at the end of Chapter 4 in the Starr textbook (Chapter 5 in the Starr/Taggart textbook) to be certain you understand the text material.
- Complete the Review Activities in this guide to reinforce your understanding of important terms and concepts. Check your answers with the Answer Key and review when necessary.

- Take the Self-Test in this guide to measure your achievement of the Learning Objectives. Check your answers with the Answer Key and review when necessary.
- Complete the Using What You've Learned activities and any other activities and projects assigned by your instructor.

Overview

In the previous lesson, you learned about the chemical foundations that form the basis for organic material and life itself. In Lesson 3, you will learn how this material is organized into the essential building blocks of all living organisms: the cells.

Cells are highly sophisticated machines with lives of their own. While each cell has the basic tools and skills to sustain itself, the cells in your body and those of other complex organisms have evolved specialized functions to aid in tasks such as nerve transmission, movement, reproduction, and digestion. Thus we have neurons, muscle cells, egg and sperm cells, and the cells of the digestive tract.

Despite the diversity of form and function, we find a remarkable consistency in the internal structure and activities of these cells. All cells contain the genetic instructions to build the molecules of life. All cells have structures to transfer energy from the biochemical breakdown of organic material and structures to manufacture the substances that the cell itself is made of. All cells have mechanisms for moving molecules in and out of the cell and for enabling the cell to interact with its environment.

Your exposure to the chemical concepts presented in Lesson 2 will help you understand what is perhaps the most basic cell structure: the “plasma membrane.” Through control of its own internal chemical composition, the cell makes it possible for some nutrients and waste materials to pass through this membrane. Materials that cannot be imported or exported passively across the membrane are actively “escorted” by transport proteins to their destination.

With this knowledge of the basic anatomy and physiology of cells, you will be ready to explore variations on the cellular theme. For example, there are important differences between the types of cells found in plants and animals (eukaryotic cells), and the cells that bacteria are made of (prokaryotic cells). The smaller size and simplified construction of prokaryotic cells makes them particularly adaptable and widespread in our world.

You will also learn about important differences between plant and animal cells. Plant cells, for example, have a cell wall surrounding the plasma membrane and a “central vacuole” that stores nutrients and toxic wastes. Plant cells need sunlight and carbon dioxide to provide metabolically useful energy, and one of the by-products of this process, oxygen, is a critical ingredient in the animal cell’s cycle of life. Your exploration of these mechanisms will continue in the next two lessons, where you will examine more closely the metabolic processes of photosynthesis and cellular respiration.

Learning Objectives

When you have completed all assignments for this lesson, you should be able to:

1. Understand the basic tenets of *cell theory*, and identify the scientific contributions that led to its development.
2. Use the term *fluid mosaic model* to describe the general structure and function of a cell's membranes, and identify the importance of membranes as a structural component of cells.
3. Define the terms *solute*, *solvent*, and *solution*, and relate them to the concentration of a solution.
4. Describe *diffusion*, including *osmosis*. Explain what causes diffusion, and identify the factors that influence its rate.
5. Define and give examples of *hypertonic*, *hypotonic*, and *isotonic* solutions, and note the direction of solute and solvent movement when any two of these solutions are separated by a selectively permeable membrane.
6. Distinguish those mechanisms by which substances move across membranes passively (without the use of energy) from active mechanisms (that require energy).
7. Contrast the general features of *prokaryotic* and *eukaryotic* cells.
8. Describe the membranous and nonmembranous *organelles* found in eukaryotic cells, and explain the general function of each.
9. Identify those features that generally distinguish plant cells from animal cells.
10. Identify some of the variations that create diversity of cells between organisms or specialization within one organism.

Viewing Notes

The video program for Lesson 3 makes an important connection between the behavior of complex organisms and the behavior of the individual cells that compose these organisms. As you will discover, almost everything an organism does can be explained by the actions of these tiny fragments of life.

Part One uses a familiar analogy to illustrate how an organism functions under hostile conditions. Like the athlete in a football game, the individual cell has developed a set of physical characteristics and skills to survive and succeed at the game of life. These characteristics and skills, while basic to all cells, have been modified and refined to enable the cell to perform a specialized function.

Sophisticated computer animation is used to take you on a guided tour of a typical animal cell to view structures and processes that can only be seen with the aid of powerful electron microscopes. It is here that you will learn about the internal structures that constitute the living machine we call the cell.

In Part Two, “Permeable Packaging,” you’ll learn more about the composition of the cellular membrane and the importance of this structure to the cell and life in general. Plant physiologist Robert Heath uses hydroponic experiments to explain the flow of nutrients through this selectively permeable membrane. The structure of the lipid bilayer and the movement of molecules across it through passive and active transport mechanisms are graphically illustrated, underscoring the concept of the cell membrane as a sophisticated gatekeeper.

In the final segment of the video program, “The Simplest Cells,” microbiologist Dennis Focht contrasts the eukaryotic cells that constitute plants and animals with prokaryotic cells, such as bacteria. Drawing on historical events, ecological models, and medical science, Dr. Focht describes the tremendous impact these single-celled organisms have had and continue to have on human survival. You’ll also discover the physiological basis for their incredible adaptability to the harshest conditions on this planet.

As you watch the video program, consider the following questions:

1. How do the physiological functions of human beings and other complex organisms reflect the basic functions of individual cells?
2. What are the fundamental internal structures of cells, and how do these structures result in the basic functions of the cell?
3. How are cells able to use similar internal structures to perform different, specialized tasks?
4. How is the cell able to import and export materials through the selectively permeable plasma membrane?
5. What are the mechanisms for packaging and actively moving molecules that would not otherwise penetrate this membrane?
6. How are plant cells and animal cells similar? How are they different?
7. What is the role of prokaryotic cells such as bacteria in the cycle of life?

8. How are the prokaryotic cells that characterize bacteria different from the eukaryotic cells that constitute plants and animals?
9. In what way do prokaryotic cells have an advantage over eukaryotic cells in the battle for survival?

Review Activities

Matching

Match the cell structures pictured below with the terms that follow. Some terms may be used more than once. Check your answers with the Answer Key and review any terms you missed.

I. Plant Cell

- | | |
|--------------------------|---------------------|
| a. cell wall | h. mitochondrion |
| b. central vacuole | i. microtubules |
| c. chloroplast | j. nucleolus |
| d. DNA and nucleoplasm | k. nuclear envelope |
| e. microfilaments | l. nucleus |
| f. endoplasmic reticulum | m. plasma membrane |
| g. Golgi body | |

II. Animal Cell

- | | |
|----------------------------------|----------------------|
| a. centriole(s) | h. mitochondrion |
| b. endoplasmic reticulum, rough | i. nuclear envelope |
| c. endoplasmic reticulum, smooth | j. nucleolus |
| d. Golgi body | k. nucleoplasm + DNA |
| e. lysosome | l. nucleus |
| f. microfilaments | m. plasma membrane |
| g. microtubules | n. vesicle |

Now match the terms listed below with the definitions that follow. Check your answers with the Answer Key and review any terms you missed.

III.

- | | | | |
|-----|---------------------|-----|----------------------|
| ___ | 1. active transport | ___ | 5. osmosis |
| ___ | 2. diffusion | ___ | 6. passive transport |
| ___ | 3. hypotonic | ___ | 7. solute |
| ___ | 4. isotonic | ___ | 8. solvent |

- a. the protein-assisted pumping of a substance through a membrane against its concentration gradient
- b. any substance dissolved in a solution
- c. a condition in which two substances in a solution, separated by a membrane, have the same concentration
- d. the net movement of like molecules in the direction of their natural concentration gradient, i.e., from higher to lower concentration
- e. the unassisted movement of a substance through a membrane following the natural concentration gradient
- f. a fluid in which one or more substances is dissolved
- g. a solution of relatively lower solute concentration than another solution
- h. the tendency of water to move from one side of a membrane to the other in response to its concentration gradient

Completion

Fill in each blank with the most appropriate term from the list for that paragraph. A term may be used once, more than once, or not at all. If a question requires two or more answers in succession, they may be in any order (unless the question indicates otherwise). Check your answers with the Answer Key and review when necessary.

1. The development of the _____ by Hooke followed by steady improvements in _____ enabled scientists to observe _____ firsthand. Their observations of plant and animal tissues led to the three basic tenets of the _____: a) that _____ organisms are composed of one or more cells and cell products, b) that the cell is the _____ unit having the properties of _____, and c) that life is perpetuated by the _____ and _____ of _____ cells.

all	life
animalcules	many
cells	micrograph
cell theory	organelles
compound microscope	organic matter
division	origin of life
electron microscope	single
growth	smallest
largest	spontaneous generation
lenses	staining techniques

2. The _____ provides a framework for understanding the structure of the cell _____. The membrane is composed of a _____, which contains primarily _____ and _____. Since solute molecules naturally move from a _____ solution to a _____ solution through the process of _____, the movement of nutrients greatly depends on its concentrations on both sides of the membrane. Specialized proteins called _____ help move nutrients against this natural tendency when needed by the cell.

carbohydrates	membrane
cell theory	messenger proteins
diffusion	mucosal barrier
endocytosis	osmosis
exocytosis	phospholipids
fluid mosaic model	proteins
hypertonic	solute
hypotonic	solvent
inorganic matter	transport proteins
lipid bilayer	wall

3. Cells are surrounded by a _____ membrane that protects their interior from the outside environment. In _____, this interior is composed of a material called _____, within which several membrane-bound compartments called _____ can be found. One of these organelles, the _____, contains the _____ for cellular reproduction. Other organelles perform specific functions. For example, the _____ produce energy for the cell, while _____ and the _____ assist in the synthesis of polypeptide chains. The Golgi body modifies these polypeptide chains into mature _____ for cellular use or secretion. Unlike eukaryotic cells, _____ such as bacteria are much simpler in construction. They do not have _____ to separate metabolic functions or a _____ to facilitate movement. Instead of using _____ and _____ to shift internal structures and produce movement, bacteria use _____ extending from their surface to move quickly through fluids.

animalcules	lysosome
centriole	microfilaments
cilia	microtubules
coelum	mitochondria
cytoplasm	mucosal
cytosine	nonpermeable
cytoskeleton	nucleolus
DNA	nucleus
endoplasmic reticulum	organelles
eukaryotic cells	plasma
flagella	prokaryotic cells
Golgi body	proteins
lipids	ribosome

4. While they are structurally similar, plant cells and animal cells are different in important respects. In addition to a plasma membrane, _____ cells have _____. Only plant cells have _____, which convert the energy of _____ to the energy of _____. Plant cells synthesize organic compounds from _____ and _____. Plant cells also have a _____, which stores amino acids, sugars, ions, and toxic wastes.

amyloplasts	glucose
animal	heat
carbon dioxide	mitochondria
cell wall	motion
central vacuole	nuclear envelope
centriole	oxygen
chemical bonds	plant
chloroplasts	proteins
chromatin	sunlight
cytomembrane system	water

Self-Test

Select the one best answer for each question. Check your answers with the Answer Key and review when necessary.

- One of the basic tenets of cell theory is that
 - all cells have the same internal structures.
 - cells are the smallest units having the properties of life.
 - cells are spontaneously generated from biochemical reactions.
 - all cells use sunlight to produce energy in the form of ATP.
- The cellular membrane is best described as a “mosaic” of proteins, lipids, and other substances that
 - is one molecule in thickness.
 - maintains equivalent fluid concentrations on both sides.
 - is unusually rigid and impermeable.
 - allows some but not all substances to pass in and out of the cell.

3. The concentration of a given solution depends on
 - a. the atomic weight of the solute.
 - b. the speed with which the solute is dissolved.
 - c. the amount of solute dissolved in the solvent.
 - d. the volume of the solution.

4. The rate at which a solute diffuses across a selectively permeable membrane depends on all of the following **EXCEPT**
 - a. the electrical charge of the solute.
 - b. the size of the cell.
 - c. the concentration of the solute on either side of the membrane.
 - d. the composition and structure of the membrane.

5. Solution A and Solution B contain the same solute and are separated by a membrane that allows the solute to pass freely. If Solution A is hypertonic relative to Solution B, you would expect
 - a. the solute to move naturally from Solution A to Solution B.
 - b. the solute to move naturally from Solution B to Solution A.
 - c. no net movement of solute in either direction.
 - d. proteins to move the solute against the concentration gradient.

6. The movement of nutrients through the lipid bilayer of the cell membrane against the concentration gradient is accomplished through
 - a. passive transport.
 - b. lysosomes.
 - c. transport or carrier proteins.
 - d. the microtubules of the cytoskeleton.

7. Prokaryotic cells differ from eukaryotic cells in that prokaryotic cells
 - a. do not reproduce by cellular division.
 - b. have a nucleus.
 - c. use organelles to separate metabolic functions.
 - d. are much smaller and more simply constructed.

8. The organelle that contains the DNA for cellular reproduction is the
 - a. nucleus.
 - b. mitochondria.
 - c. Golgi complex.
 - d. endoplasmic reticulum.

9. Unlike animal cells, plant cells use chloroplasts
 - a. for cellular reproduction.
 - b. to provide useful energy and organic compounds.
 - c. to eliminate excess carbon dioxide.
 - d. to store amino acids, lipids, and sugars.

10. Cells that have specialized functions, such as fat cells and muscle cells, are able to perform these functions because
 - a. they have evolved new structures to accommodate these functions.
 - b. they form cell “clusters” that behave differently from single cells.
 - c. the nucleus “reprograms” the organelles of each cell as needed.
 - d. they make greater or lesser use of the same basic internal structures.

Using What You've Learned

Based on your own interests or your instructor's requirements, complete one or more of the following activities.

1. Using a container of water and a small amount of colored ink or food dye, observe how molecules diffuse from areas of greater concentration to areas of lesser concentration. Use an eyedropper to place a few drops of the dye into the container and note how the dye diffuses through the water.
2. Design a hypothetical cell that would function best under each of the conditions listed below. Sketch or describe how the size, structure, and function of the cell membrane and organelles would be affected in each case.

Condition A: Desert—high sunlight, high temperature, and extreme drought
Condition B: Ocean bottom—saline, extreme pressure, and minimal light
Condition C: High altitude—near weightlessness and minimal atmosphere
3. Visit the library and scan recent science publications for current research and scientific applications in the field of cellular physiology. Select the most interesting article and construct a brief report summarizing the principal outcomes.

4. Using the data presented in your textbook and common materials to construct scale models, compare the size of typical prokaryotic and eukaryotic cells. Then construct a scale model of a eukaryotic cell and its major organelles. How much of the cell's volume is occupied by these organelles?
5. Based on your knowledge of the human body and observations of other organisms in nature, try to list as many different cell types as you can. When you have completed the list, review each cell type and imagine how that cell's structure has been modified to accommodate this role.

Challenge Questions

1. How do the physiological functions of complex organisms reflect the basic functions of individual cells?
 2. How are cells able to perform specialized tasks?
 3. How does the structure of a cell reflect its function? How do the cell's internal organelles illustrate this connection between form and function?
 4. What mechanisms can the cell use to import and export materials through the selectively permeable plasma membrane?
 5. What are the important differences between eukaryotic cells and prokaryotic cells? Between plant cells and animal cells?
 6. What is the role of prokaryotic cells such as bacteria in the cycle of life?
10. d (Objective 10; page 56 S; pages 58–61 S/T; video program)

Answer Key

Matching

I.

- | | | |
|------|-------|-------|
| 1. g | 6. b | 11. f |
| 2. n | 7. l | 12. i |
| 3. e | 8. k | 13. m |
| 4. c | 9. d | 14. a |
| 5. h | 10. j | |

II.

- | | | |
|------|-------|-------|
| 1. g | 6. l | 11. e |
| 2. f | 7. i | 12. b |
| 3. m | 8. j | 13. c |
| 4. h | 9. k | 14. n |
| 5. a | 10. n | 15. d |

III.

- | | | |
|------|------|------|
| 1. a | 4. c | 7. b |
| 2. d | 5. h | 8. f |
| 3. g | 6. e | |

Completion

1. compound microscope, lenses, cells, cell theory, all, smallest, life, growth, division, single
2. fluid mosaic model, membrane, lipid bilayer, phospholipids, proteins, hypertonic, hypotonic, diffusion, transport proteins
3. plasma, eukaryotic cells, cytoplasm, organelles, nucleus, DNA, mitochondria, ribosomes, endoplasmic reticulum, proteins, prokaryotic cells, organelles, cytoskeleton, microtubules, microfilaments, flagella
4. plant, cell walls, chloroplasts, sunlight, chemical bonds, water, carbon dioxide, central vacuole

Self-Test

(S after page numbers refers to the Starr textbook, S/T after page numbers refers to the Starr/Taggart textbook)

1. b (Objective 1; page 51 S; page 54 S/T; video program)
2. d (Objective 2; pages 52–53 S; pages 54–55, 80–81 S/T; video program)
3. c (Objective 3; page 84 S; page 84 S/T)
4. b (Objective 4; pages 51–52, 84–85 S; pages 54–55, 84–85 S/T)
5. a (Objective 5; pages 52, 84–85 S; pages 54–55, 84–85, 88–89 S/T)
6. c (Objective 6; page 53 S; pages 80–81 S/T; video program)
7. d (Objective 7; page 70 S; page 54 S/T; video program)
8. a (Objective 8; pages 56, 60–61 S; page 62 S/T; video program)
9. b (Objective 9; page 65 S; page 67 S/T)
10. d (Objective 10; page 56 S; pages 58–61 S/T; video program)