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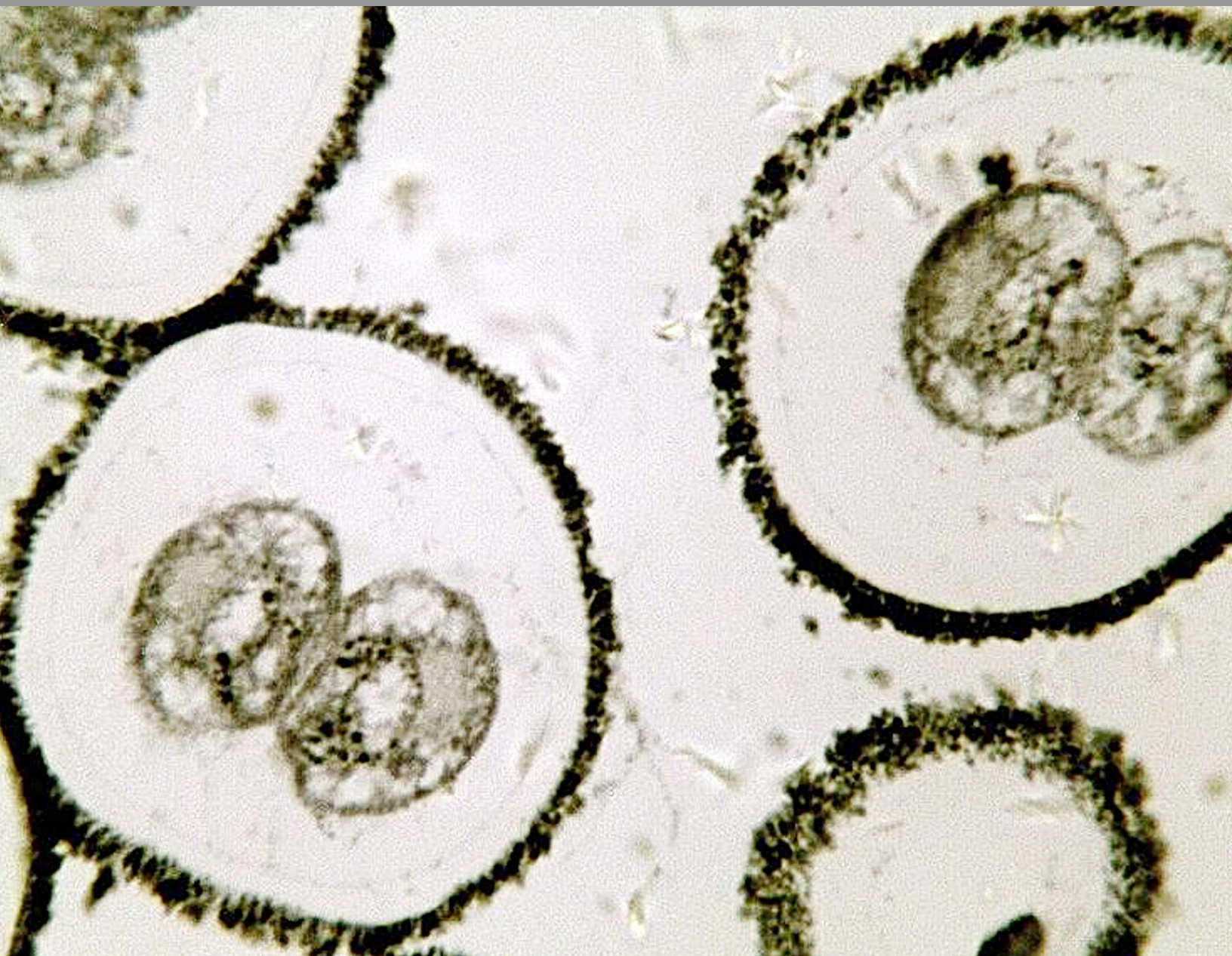
Teacher's Guide



Human Biology Lives of Cells Teacher's Guide

The Program in Human Biology,
Stanford University, (HumBio)

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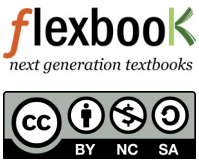

AUTHORS
The Program in Human Biology,
Stanford University, (HumBio)

CHAPTER 1 Introduction to Lives of Cells - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

1.1 Overview

Human Biology: An inquiry-based guide for the middle school student.

Developed by the Program in Human Biology at Stanford University and

EVERYDAY LEARNING®

Contents

Text Authors

Mary L. Kiel, Stan Ogren, Ellen Porzig

Activity Authors

Stan Ogren, Ellen Porzig, Geraldine Horsma, Marjorie Gray

GroupWork Authors

Nicole Holthuis, Julie Bianchini, Heidi Ballard, Rachel Lotan

Principal Investigator H. Craig Heller, **Project Director** Mary L. Kiely

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Everyday Learning Development Staff

Editorial

Steve Mico

Leslie Morrison

Susan Zeitner

Production/Design

Fran Brown

Annette Davis

Jess Schaal

Norma Underwood

Additional Credits

Project Editor: Dennis McKee

Shepherd, Inc.

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1.2 Acknowledgments

Stanford University

H. Craig Heller-Lorry I. Lokey/Business Wire Professor of Biological Sciences, Professor of Human Biology, Chair, Department of Biological Sciences and Associate Dean of Research-Principal Investigator

Herant Katchadourian-Professor of Psychiatry and Behavioral Sciences and Professor of Human Biology-Project Steering Committee

Mary L. Kiely-Senior Academic and Research Program Officer, Program in Human Biology-Project Director

S. Shirley Feldman-Senior Lecturer, Program in Human Biology and Senior Scientist, Department of Psychiatry and Behavioral Sciences-Project Steering Committee

Teacher Consultants/Curriculum Developers

Heidi Ballard-Stanford Program in Human Biology (1991-93), Henry M. Gunn High School, Palo Alto

Julie Bianchini-Stanford School of Education (1991- 95), University of California, Santa Barbara

Marjorie Gray-Egan Intermediate School, Los Altos

Nicole Holthuis-Stanford School of Education

Geraldine Horsma-Henry M. Gunn High School, Palo Alto

Rachel Lotan-Stanford School of Education

Modell Marlow Andersen-William H. Crocker Middle School (1991-95), Hillsborough City School District, Hillsborough

Stan Ogren-Menlo-Atherton High School, Atherton (retired, 1997)

Susan Schultz-Menlo-Atherton High School, Atherton (1991-95), Stanford School of Education

Tami Warr-Corte Madera School, Portola Valley

Ken Whitcomb-William H. Crocker Middle School, Hillsborough (retired, 1996)

Faculty Authors

Rob Blair-Stanford Center for Conservation Biology, Department of Biological Sciences (1994-95) Department of Zoology, Miami University of Ohio

Angelo Collins-Stanford School of Education (1987- 90), School of Education, Vanderbilt University

William H. Durham-Program in Human Biology and Chair, Department of Anthropology

S. Shirley Feldman-Program in Human Biology and Department of Psychiatry and Behavioral Sciences

Hill Gates-Department of Anthropology

H. Craig Heller-Chair, Department of Biological Sciences and Professor, Program in Human Biology

Patricia P. Jones-Department of Biological Sciences, Chair (1993-97)

Herant Katchadourian-Program in Human Biology and Department of Psychiatry and Behavioral Sciences

James V. Lawry-Program in Human Biology (1987-93)

Ellen Porzig-Program in Human Biology

Arthur Wolf-Department of Anthropology

Project Staff

Leah Meagher-Senior Project Assistant (1996-98)

Hao-Chau Tran, Susan Kalter and Tom Keating-Project Assistants (1990-96)

Tom McKean-Electronic Network (1993-95)

Lorraine Morgan-Associate Director (1987-93)

Beth Dungan-Research Assistant, Formative Evaluation (1992-95)

Test Site Middle Schools and Teacher Teams

Anson Jones Middle School-San Antonio, Texas

Linda Pruski, Carron Collier, Laura Boyd, Jennifer Perez, Leacy Piper, Elizabeth Godwin, Cynthia Smelser, Sherry Thompson, Etta Tricksey-Charles Burling, Principal (1991-95)

Azalea Gardens Middle School-Norfolk, Virginia

Margaret Finney, Kelly Graves, Betsy McAllister, Sundra Pitts, Michelle Eichenberg-Frank Steadman, Principal, Jeane Dughi, Science Coordinator

Central Park East Secondary School-New York, New York

Angelo Campanile, Nathan Tantleff, Mark Gordon, Aurea Hernandez-Webster, Judi Gimpelson, Bridgette Bellettiere, Debbie Smith-Debbie Meier, Principal (1991-93), Paul Schwarz, Principal

Dozier Middle School-Newport News, Virginia

Donna Harrison, Gay Meeks, Denise Fehrenbach, Chris Dawson-Steve Chantry, Principal (1991-94), Thomasena Woods, Science Supervisor, Diane Robinson, Hampton Roads University

Egan Intermediate School-Los Altos, California

Marjorie Gray, Leslie Crane, Cynthia Ford, Lenore Giguiere, Linda Glynn, Paul Gonella, John Barbano-Marianna Andersen, Principal (1991-93), Brenda Dyckman, Principal

East Lyme Middle School-Niantic, Connecticut

Creig Petersen, Joan Cole, Eunice Taylor, Karen Twitchell, Kathy Ceitanno, George Williams-Jerry Belair, Principal

O'Farrell Community School-San Diego, California

Sherry Wachna, Mary Clauss, Irma Jones, Tara Solie, Liz Laughlin, Lenora Smith, Kathy Lathus, Barbara Munson-Bob Stein, Principal

Overland Trail Middle School-overland Trail, Kansas

Lynn Granger, Robin Hodges, Teresa Hogan, Jackie Lenz-Mary Gatewood, Principal (1991-93), Kathleen Currence, Principal, Sue Thompson, Director of Middle Level Education- Blue Valley School District

Picacho Middle School-Las Cruces, New Mexico

Freddie Dresp, Jimmie Lou Buescher, Starla Lester, Dorothy Weister, Sherman Betts-Erlinda Martinez, Principal, Kathryn Vigil, Assistant Principal, Bonnie Votaw, Curriculum Supervisor

St. Elizabeth Catholic School-Dallas, Texas

Ann Marie McDonnell, Carolyn Witte-Charles Cooper, Principal (1991-95), Thelma Cooper, Assistant Principal

South Oldham Middle School-Crestwood, Kentucky

Pamela Jett, Phyllis Vaughn, Diana Arnold, Holly Johnson, Nancy Souza, Cheryl McCall, Joanne Taylor-Michael Denny, Principal, Dan Ochs, University of Louisville, Betty Edwards, Director of Curriculum and Assessment, Kentucky State Department of Education

Wakulla Middle School-Crawfordville, Florida

Angie Williams, Li Anne Douglas, Margaret Worrell, Suzanne Edwards, Regina Strickland-Robert Myhre, Principal

William H. Crocker Middle School-Hillsborough, California

Modell Marlow-Andersen, Ken Whitcomb, Peter Martin, Donna Hower, Gary Lynes, Lisa Mandelbaum, Donna Izzo, Mary Fish, Steve Oshita-Marilyn Loushin-Miller, Principal (1991-92), Dan Kreuzer, Principal (1992-95)

Advisory Board Members

David A. Hamburg, Chair *Carnegie Corporation of New York*

Merton Bernfield *Harvard Medical School*

Gene Carter *Association of Supervision #38; Curriculum Development*

Gordon Cawelti *Consultant in School Restructuring*

Peter Cortese *Centers for Disease Control*

Betty Edwards *National Middle School Association (1992-94) Kentucky State Department of Education*

John W. Farquhar *Stanford Center for Research in Disease Prevention*

E. Harold Fisher *National School Boards Association (1993)*

William Foege *Carter Center, Emory University*

Paul DeHart Hurd *Stanford School of Education*

Laurel Kanthak *National Association of Secondary School Principals*

Joshua Lederberg *The Rockefeller University*

John Moore *Department of Biology University of California, Riverside*

M. Roy Schwarz *American Medical Association*

George Tressel *Education Consultant*

Former Members

William Hendee (1988-92) *American Medical Association*

Lloyd Kolbe (1988-92) *Centers for Disease Control*

Jeanette Phillips (1990-93) *National Middle School Association*

Leonard Rovins (1988-92) *Summit, Rovins and Feldman*

Robert Shockley (1988-90) *National Middle School Association*

Marshall Smith (1988-92) *Stanford School of Education*

Dedication

The faculty, staff, and teachers of Stanford University's Human Biology Middle Grades Life Science Curriculum Project dedicate the publication of the HumBio Curriculum in memory of our colleagues and friends, Mrs. Donna Harrison and Dr. Mary Budd Rowe. Donna was the lead science teacher at Dozier Middle School, the project test site school in Newport News, Virginia. She was an outstanding teacher, a community leader, a devoted wife and mother, and a wonderful human being. Her involvement in the HumBio Project enriched the curriculum materials and brought great joy to our lives. Although her life ended suddenly and tragically, the inspiration she gave to all who knew her will live on in what we do to improve the education of children and youth. Mary Budd Rowe was our most distinguished science education colleague and our dear friend. She guided the early organizational stages of the project as a group of university scientists attempted to address issues of middle level science education. Her unbridled enthusiasm for the education of children always reminded us of the important purpose of our work. Mary continued her unwavering support of the HumBio curriculum until her passing in June of 1996.

1.3 Preface

Stanford University's Middle Grades Life Curriculum Science Project began in 1986 with the vision of David A. Hamburg, M.D., then President of Carnegie Corporation of New York. A new wave of science education reform was gathering momentum following the release of *A Nation at Risk* by the United States Department of Education and *Educating Americans for the Twenty-First Century* by the National Science Board. Dr. Hamburg brought together the concerns of scientists and science educators over the watered down, vocabulary-laden life science curricula that were typical of middle level science courses at that time with broader public concern over large and increasing numbers of adolescents who engaged in high-risk behaviors leading to school failure, teen pregnancy, and other health problems. Because of his leadership in developing Stanford's undergraduate Program in Human Biology and his interests as a physician and scientist in the major physiological and behavioral transitions in the lives of children, Dr. Hamburg believed that a rigorous middle grades life science curriculum focused on human biology, and where possible on the adolescent, not only would greatly improve the science taught at this level, but through its relevance would capture the interest of this age group.

Initial work on the Human Biology (HumBio) Middle Grades Life Science curriculum brought together faculty, staff, and students from Stanford's Program in Human Biology and its School of Education with local middle and high school teachers. The curriculum development team was enriched in 1991 by twelve interdisciplinary teams of middle level teachers from diverse test site schools across the country. These teams became our most valued collaborators. The teachers attended annual two week summer institutes at Stanford between 1991 and 1994 and used the draft curriculum units in their classes between 1991 and 1995. The teachers and their students provided extensive formative evaluation data on the field-test materials, which has shaped the final student and teacher versions of the units that make up the HumBio curriculum. Using HumBio units as a starting point, many teams also created their own innovative, interdisciplinary materials, which they taught across the middle level curricula in their schools.

The Project's Advisory Board provided insightful advice on the development of the curriculum from the unique perspectives of the professional associations, the institutions, and the fields its members represented. We are grateful to all of those who served for periods of time during the past seven years. We also would like to express our appreciation to the education consultants from universities, the National Middle School Association, and the California State Department of Education who made presentations and worked with the teacher teams during the summer institutes at Stanford. C. Stuart Brewster served with great distinction as our advisor on publication. We are indebted to him for his keen insights and good advice.

The Project faculty, the staff, and the teachers contributed more to the development of the HumBio Curriculum than anyone could have imagined before this work began. Their expertise, determination, and dedication to improving the education of adolescents were inspirational. Supporting the curriculum development team and the test-site teachers were wonderful groups of Stanford undergraduates from the Program in Human Biology. They helped to ensure a productive and pleasurable working environment, which was an essential part of the success of the summer institutes.

To be sure, none of this work would have been possible without funding from Carnegie Corporation of New York, the National Science Foundation, and most recently The David and Lucile Packard Foundation. On behalf of the entire Project team we would like to thank these foundations and the program officers who have worked with us over the years for their support. As always, the final content of this curriculum is the sole responsibility of the Stanford University Middle Grades Life Science Curriculum Project and does not necessarily reflect the views of Carnegie Corporation of New York, the National Science Foundation, or The David and Lucile Packard Foundation.

H. Craig Heller *Principal Investigator*

Mary L. Kiely *Project Director*

January, 1998

Stanford, California

1.4 Letter to the Teacher

Dear Teacher:

As a cell developmental biologist, I hope your students become fascinated by how cells become specialized and how they work. Cells can be very interesting to students, once they jump past the size issue. Microscopes can help to make cells seem tangible, although most of the activities in this unit are designed to teach without the use of any equipment. One disadvantage of thinking of cells only as they appear in a microscope is that typically those cells are dead. Living cells are much more interesting, since they can move, crawl, and some cells, such as nerve cells with their spectacular axons, can send out long processes.

As you know, cells are the units of human life. Without cells there would be no life. Each of us originated from a single cell. One of the first activities that students experience investigates the questions, "What would it be like if we were made up of a single cell?" and "Why is it necessary to have millions of tiny cells to build a human?"

Your students can probably already name important cell types from other parts of the curriculum, such as nerve cells, heart muscle cells, sperm, and eggs. They know humans develop from a single cell. Their curiosity can be reawakened to focus on questions such as those that follow. How can one cell, the fertilized egg, lead to such different kinds of cells in bone, in blood, and in the lens of an eye? How do these cells become specialized? How does cellular diversity happen?

The activities in this unit are more important than the text. You know your own students and can anticipate which of the various activities will be best for them. Some are fun and others are more challenging. There is a broad range of activities. Thus each student should find some aspect of cells that is enjoyable and stimulating to investigate.

This unit has five sections, so you may want to select the material that best meets the needs of your class. Some students may want to investigate the artistic side of cells. For example, you may choose to use the Mini Activity in which soap bubbles represent cells. Other students may want to take a mathematical approach to investigating cells. For them, activities that deal with surface area and volume of cells, such as Activity 1-1, may be most interesting.

Teaching from specific questions about cells is a great way to approach this unit. I hope that you and your students will come up with questions that this unit does not answer. I hope you will ask students to keep a journal of their questions about cells. As they go through middle school, high school, and college, there will be new answers for many of these questions. One good question often leads to others. Someday they may actually be involved in finding answers to some questions.

Best Wishes,

Ellen Porzig

1.5 Unit Planning

Content Overview

Lives of Cells: What do they look like? What do they do? Why are cells important?

Students address these and other important questions as they investigate the structures and functions of eukaryotic cells. They begin by observing cells from different tissues under a light microscope to identify common structural features. They then distinguish one cell type from another by differences in their shape and size. They learn how cells of the same type associate to form tissues, how different kinds of tissues associate to form organs, and how organs work together to form systems. Students answer the question, "Why are cells so small?" by exploring what happens to the efficiency of cells when they increase in size, as students investigate the relationship between the surface area of a cell and its volume. Students then learn about essential cell parts and cellular organelles. Using their knowledge of cell parts, they build a three-dimensional (3-D) model of a cell and relate the structure of the cell they choose to its function in the human body. Students then go on to study cell activities and the function of enzymes in facilitating chemical reactions within cells. Students explore the physical properties of DNA by isolating it from thymus tissue. They also build a model of the DNA double helix and then simulate DNA replication. They study the genetic code stored in DNA, how information in genes is transcribed into messenger RNA, and how mRNA is then translated into protein. In the final section of the unit, students consider the health of cells and why it is important in maintaining internal balance, homeostasis, within the body. They explore DNA mutations and distinguish their potential effects when the mutations occur in somatic cells, as compared with mutations that occur in gamete cells. They study genetic diseases, and then they follow the disease process in cystic fibrosis, as an example of how genetic disorders affect the normal functions of cells. Students then learn how normal cells in the body may be transformed into cancer cells by factors both in the environment and from within the body. They compare the differences between the structure and functions of normal cells and cancer cells, and they learn how scientists predict the risks of developing certain types of cancer during a lifetime. Using their knowledge of cancer, students determine ways they can decrease their risk of developing this disease.

How Is This Unit Organized?

Section 1 introduces students to cells as the building blocks of life. Students explore the similarities and differences among cells comprising different tissues. They study how cells are organized and work together to form tissues, organs, and systems. The text and activities help students determine what happens when a cell increases in size, with a focus on the relationship between its surface area and volume.

Section 2 describes cell parts and their functions. Students investigate the composition and function of the cell membrane. Students learn about the properties of the lipid bilayer with its embedded proteins, and relate this structure to its functions as a semipermeable membrane that allows some substances to pass through it, while others are blocked. Students study the fluid movement of proteins within the bilayer. They then apply their knowledge of cell parts in building a three-dimensional model of a cell.

Section 3 explores important activities of cells including cellular respiration, diffusion, osmosis, active transport, and cell division. Students investigate the role and action of enzymes and factors that affect their functions in the cell. They simulate and compare the process of mitosis in somatic cells with the process of meiosis, which produces gamete cells.

Section 4 introduces students to DNA and the genetic code. They explore the physical properties of DNA isolated from thymus tissue and then build a paper model of the DNA double helix and use it to simulate the replication

of DNA. Students study the organization of the genetic information stored in the DNA molecule and simulate the transcription of a gene into an mRNA molecule and its translation into protein at the ribosomes.

Section 5 explores the important function of cells in maintaining internal balance, or homeostasis. Students consider factors within the body and in the environment that affect the health of cells. Students compare the appearance of cells in normal and diseased tissue. They learn about mutations in the DNA molecule and their potential effects in somatic cells and in gamete cells. Cystic fibrosis is studied as an example of an inherited genetic disorder. Students explore cancer and its effects on cells. They consider how scientists predict the risk for developing certain types of cancer, and use this information to determine ways to reduce their risk of developing this disease.

Why Teach This Unit?

There are thousands of genetic disorders that affect the function of cells in the human body.

For example, cystic fibrosis is an inherited genetic disorder that affects the normal function of cells in the lungs and other organs. Although treatments are far better today and more innovative treatments are under development, most patients with cystic fibrosis do not live beyond their twenties. The Cystic Fibrosis Foundation estimates that the disease occurs in 1 in 3,300 live births in the United States. One in four deaths in the United States is due to some form of cancer (American Cancer Society, 1998).

The National Cancer Institute estimates the overall annual costs of cancer to be more than $107 billion (1998).

Due to research on cells, the knowledge generated, and its application in the treatment, 4 out of 10 new cancer patients are expected to be alive 5 years after diagnosis (American Cancer Society, 1998).

Students can apply their knowledge of the structure and functions of cells and factors that affect the health of cells to issues of how to reduce their risks of developing certain types of cancer (by not smoking, eating a low-fat diet, and reducing exposure to toxic chemicals in the environment and to all types of air pollution).

TABLE 1.1: Unit Activities and Key Ideas

Section	Key Ideas	Activity
1. **Building Blocks of Life** What are cells?	• Cells are the basic unit of life, each with a specific purpose. • Cells, tissues, organs, and systems work together to form the structures and perform the functions of the human body. • Cells are small, thus maintaining a vast surface area per unit volume to enhance cell efficiency.	**Mini Activity:** Using a Microscope to See Cells **Mini Activity:** Relative Size of a Cell **Mini Activity:** Imagine a One-celled Human **Activity 1-1:** Why Are Cells Small? **Mini Activity:** How Changes in Surface Area and Volume Affect Cells with Different Shapes

TABLE 1.1: (continued)

Section	Key Ideas	Activity
2. **Cell Parts and Their Functions** What is the structure of cells?	• Cell parts and organelles are responsible for the specific functions of eukaryotic cells. • The cell membrane is composed of a bilayer of lipids and proteins arranged in an orderly manner. • The substances that go into or out of a cell are determined by the structure of the cell membrane.	**Mini Activity:** A Drawing or Model of a Cell Membrane **Mini Activity:** Soap Bubbles **Mini Activity:** What Does Each Part of a Cell Do? **Activity 2-1:** Making a Cell Model
3. **Cell Activities** What are some cell functions?	• The life of a cell depends on the activities that take place within it and also on the environment surrounding it. • Enzymes help chemical reactions take place inside the cell. They help build products, make copies of molecules, and carry out cell functions efficiently. • The selectively permeable cell membrane allows water to pass through it, but not large molecules dissolved in water. • Passive and active transport are the processes by which substances move in and out of the cell. • Cellular respiration requires oxygen and produces ATP, the energy needed for the cell to do its work. • Cell division is one of the important events of the cell cycle.	**Activity 3-1:** Catalysts and Enzymes in Your Life **Mini Activity:** Transport of Nutrients: Exploring Diffusion **Activity 3-2:** Cell Division-Double or Nothing **Mini Activity:** Mitosis in Action **Enrichment 3-1:** Exploring Osmosis

TABLE 1.1: (continued)

Section	Key Ideas	Activity
4. **DNA and the Genetic Code** How important is DNA in the functioning of a cell?	• The genetic information contained in cells is stored in DNA molecules and copied accurately so that each daughter cell receives the same information. • The genetic code is represented by sequences of triplet nucleotides in the DNA molecules. • Different cell types in your body use or express different portions of your DNA called genes. Genes code for the production of specific proteins in the cell. • The transcription of mRNA and its translation at the ribosomes are the processes involved in making proteins.	**Activity 4-1:** Removing DNA from Thymus Cells **Activity 4-2:** Building and Using a DNA Model **Mini Activity:** Coding **Mini Activity:** Building a Protein Model **Enrichment 4-1:** Making Protein
5. **The Health of Cells** In what ways does your general health depend on the health of your cells?	• Cells have important functions in maintaining homeostasis, or internal balance, within the body. Factors that affect the functions of cells come from within the body and from the external environment. • A permanent change in the DNA of a cell is called a mutation. • Cancer cells are different from normal cells in how they recognize other cell types, reproduce, move, and respond to chemical signals. • Individuals can lower their risk of developing certain kinds of cancer by limiting their exposure to specific cancer-causing agents and making wise lifestyle choices.	**Activity 5-1:** Cells Gone Awry

Teacher's Guide Overview

This *Lives of Cells* unit is built around a variety of student activities. Text material can be used to introduce, reinforce, and extend the concepts developed in the activities. The activities are the foundation of this unit, so the unit's success depends on students' involvement in the activities. Embedded activities are interrelated, since the concepts developed in one may be applied in another.

Section Planning

For each section, you'll find extensive advance planning for the student activities and the section topic. Key ideas, section objectives, background information, suggestions for introducing activities, and the materials needed for each activity are listed on the Section Planning page. Review this information ahead of time to ensure that materials for each activity are available when you need them.

Support for Embedded Activities

Embedded activities are those activities contained or "embedded" in the student edition. Procedures for each embedded activity are contained in the student edition. In the Teacher's Guide, you'll find activity planning information, activity assessment, and student reproducible pages for each embedded activity.

Enrichment Activities

Enrichment activities are activities found in the Teacher's Guide only. These activities are designed to extend and enrich students' learning experiences. Complete Enrichment activities, including Teacher Activity Notes and student procedures and reproducible pages, are located at the end of each appropriate section of the Teacher's Guide.

GroupWork Activities

Learning science is a process that is both individual and social. Students in science classrooms often need to interact with their peers to develop a knowledge of scientific concepts and ideas, just as researchers, engineers, mathematicians, and physicians work in teams to answer questions and solve problems. The GroupWork activities of the HumBio Curriculum for the Middle Grades have been developed to foster a collaborative environment for groups of students. Students plan experiments, collect and review data, ask questions and offer solutions, use data to explain and justify their arguments, discuss ideas and negotiate conflicting interpretations, summarize and present findings, and explore the societal implications of the scientific enterprise. In short, GroupWork activities provide an environment in which students are "doing science" as a team.

For more information, refer to "Using GroupWork Activities" on TE page 85. The specific GroupWork activities for this unit can be found on TE pages 88-115.

Projects

The research and action projects in HumBio are varied and provide students with time to explore a particular topic in depth. With Projects, students have the opportunity to take a position based on knowledge gained through research, debate an issue, and devise a plan of action. In this way, students can apply what they are learning to larger issues in the world around them.

Projects for this unit include

- Research Questions
- Cell Models

Assessment Overview

Within each section of the unit there are suggestions for assessment that can be used individually or in combination to develop a complete assessment package. The list below describes the variety of assessment tools provided.

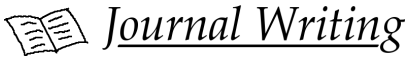
Apply Your Knowledge questions appear throughout each section. They can be used as homework assignments and as ways to initiate a class discussion. These questions are designed to assess

- communication skills
- depth of thought and preparation
- problem-solving skills
- ability to apply concepts to related or big ideas
- how well students relate their new knowledge to their different problems

What Do You Think?

These questions appear in each section. They provide students with opportunities to think and write about the concepts they are learning in a larger context. You can use these questions to assess

- writing skills
- problem-solving abilities
- creativity and depth of thought
- the ability to analyze and summarize



Journal Writing prompts are suggested throughout the unit. These prompts provide opportunities for students to write critically and creatively about concepts and issues. The writing products can be used to assess

- writing skills
- depth of thought
- the ability to explain and expand and on concepts and issues

Review Questions

Review Questions are located at the end of each section. These questions can be used for written responses or as the basis for class discussion. These questions are designed to assess content knowledge and whether students can explain the concepts explored in the section.

Activity-Based Assessment

Inquiry-based student-centered activities are the foundation of the *Human Biology* program. The unit is rich with relevant and exciting activities that introduce, support, or reinforce concepts students are exploring. Within the Teacher's Guide, you'll find extensive teacher information, including assessment strategies, for each type of activity:

- Embedded Activities
- Enrichment Activities
- Mini Activities

- GroupWork
- Projects

Building a Protein Model Collect 50 pop beads or linker cubes. If possible, select pop beads having 20 different colors to represent the 20 different amino acids. Use any combination of colored pop beads to make a chain of 50 beads. Check with your classmates to see if anyone else has the same sequence of colored beads. What does this tell you about the number of possible proteins that can be made from 20 different amino acids?

You can use students' products to assess their progress. These products include models, simulations, observations and reports of laboratory investigations, role plays, written responses to questions and written observations, student-designed explorations and procedures, poster presentations, and classroom presentations.

PORTFOLIO ASSESSMENT

You may want to have each student develop a portfolio for the unit. Portfolio assessment is an excellent way to assess the student as he or she progresses through the unit. Although there are many opportunities to select a variety of students' products, the following list shows one possible assessment portfolio for this unit:

- Written responses to three *What Do You Think?* questions
- An analysis of the student's two favorite Activities and how those activities helped the student learn an important concept
- Written responses to one *Apply Your Knowledge* question from each section
- Reports from three laboratory investigations such as

Activity 3-1: Catalysts and Enzymes in Your Life
Activity 4-1: Removing DNA from Thymus Cells
Activity 5-1: Cells Gone Awry

- Two examples of constructing a model from the following:

Activity 2-1: Making a Cell Model
Activity 4-2: Building and Using a DNA Model

- Two examples of calculations from the following:

Activity 1-1: Why Are Cells Small?
Mini Activity: How Changes in Surface Area and Volume Affect Cells with Different Shapes

Getting Started

Keep Students Interested. Encourage students to read the text: It is the story line that ties all of the content together. Every effort has been made to make the text interesting to students and appropriate to their reading level. Text material can be used to introduce, reinforce, and extend the concepts addressed within the activities.

The success of the unit depends on the completion of at least the Embedded activities. And keep in mind that some activities are related since the data obtained in one may be used in another.

Plan Ahead. The unit is activity-based, and you can select the activities that will best meet your class' needs. The activities are listed in the Unit Matrix on page xiv and in the Activity Index on page 122. Mini Activities are shorter and can be done with minimal teacher input; they are located in the margin of the student edition. The Embedded

activities in the student text are investigations that require some planning and setup time; these are the essential activities within the unit. Other investigations called Enrichment activities are located at the end of each section in the Teacher's Guide. Enrichment activities expand student knowledge of the concepts explored in the given section.

A variety of projects were designed to extend the content of the unit. These include ongoing class projects, school projects, and/or community projects. Projects are located at the end of the Teacher's Guide, beginning on page 116.

Customize the Unit. Each section of this unit builds upon knowledge gained in the previous sections. Teaching timelines are provided on TE pages xxii-xxiii. The first timeline on TE page xxii demonstrates how to complete this unit within a threeweek schedule. The timeline on TE page xxiii demonstrates how to complete this unit within a five-week schedule. Both of these timelines highlight the essential activities. If your class has time to study the unit over a longer period of time, many additional activities are available.

Allow Time for Projects. Consider having students start projects at the beginning of the unit and then prepare those projects for presentation as a culminating event.

Use Current Events. Ask students to bring in newspaper and magazine articles that relate to what they are studying each week. Relating the unit content to current events helps students see that what they are doing in class is, in fact, relevant to their lives outside of school. Students can use current events to make group scrapbooks, bulletin boards, and posters or to develop class presentations.

Make a "Question Box" Available. Have students write down questions they have about what they are investigating and put them in the box. At appropriate times select questions and read them to the class to generate discussion. These questions can also be used to initiate class research projects.

Use a Variety of Resources. We encourage you and your students to use a wide variety of sources for information. The activities provide rich opportunities for students to explore a variety of concepts. The more students incorporate information from resources outside the classroom, the richer their learning experiences will be. Use computer services for gathering student and teacher information, for networking with students in different schools and with community resources, and for contacting experts in the field under study. A list of resources can be found on page 119 of this Teacher's Guide.

Make Career Connections. Encourage students to investigate careers related to the content of the unit. Invite scientists, physicians, and technologists working in the field to come to your classroom to discuss career opportunities, their research, and specific topics of interest.

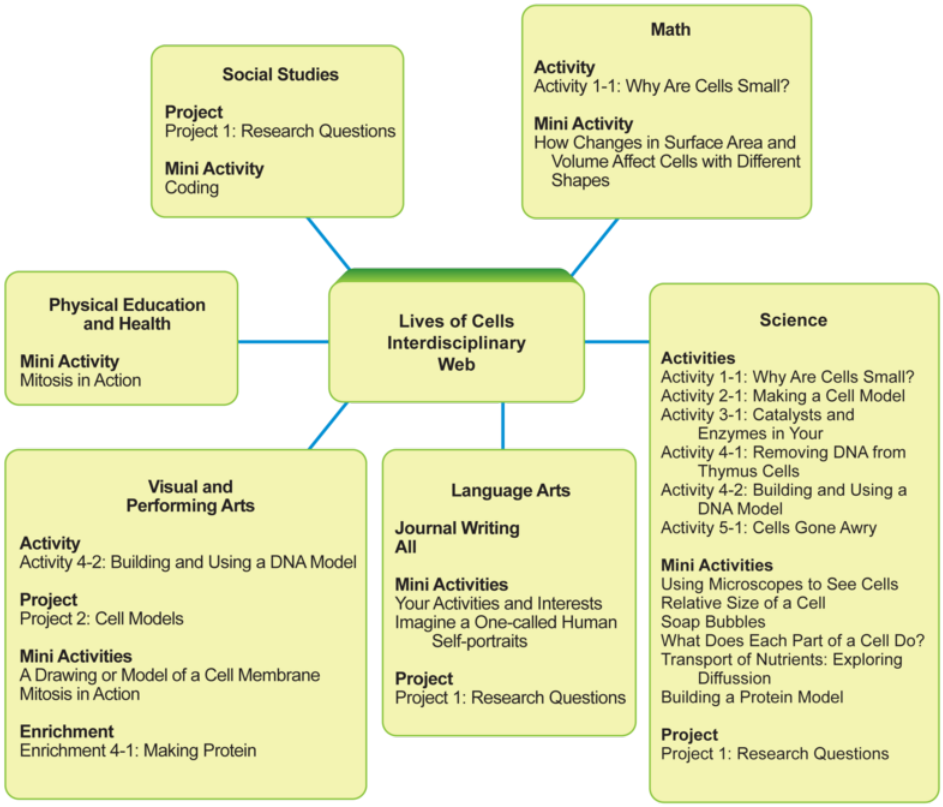
Plan for Field Trips. Field trips to local hospitals, industrial sites, or universities need, of course, to be arranged well in advance. Contact the public affairs offices of these institutions for assistance.

Address Health Concerns. Be aware of any special health problems your students may have. Some students may have health conditions that would make it uncomfortable for them to participate in certain activities, such as those that require exercise or that relate directly to their particular health problems. For students unable to participate fully in these activities you may wish to create an alternative assignment or have them use data from another group. If the class is appropriately prepared, the affected students may want to share information about their special circumstances with the class in order to increase empathy and knowledge of all students.

Connect with Other HumBio Units. The units covering human physiological systems, cell biology, and genetics are related. There are many opportunities to make connections among the concepts taught in these units. Similarly, the three units covering the biological, behavioral, and social aspects of adolescent development can be taught in sequence.

Connect with Other Disciplines. The interdisciplinary web provided is a guide for planning if your school uses an interdisciplinary team approach. The Social Studies web classifies the unit's activities and projects by related discipline-language arts, math, social studies, physical education, health/nutrition, and visual/performing arts, and science. For interdisciplinary planning, schedule meetings with your team early. You are encouraged to tap the talents and interests of your team members as well as of your unique school and community resources in developing other suitable activities for this unit.

Connect with the Home. Give special attention to the unit activities as a means of involving family and community members. Also, encourage your students to take selected Apply Your Knowledge questions and Mini Activities home for further exploration.



Teaching Timelines

You can use these timelines as a place to start in designing your own timelines, or you can use them as they are laid out. If you're planning your own timeline, consider the inclusion of the Embedded activities first. The "Embedded activities" are included in the student edition. The Enrichment activities, GroupWork activities, and Projects can then be included, depending on your time restrictions. The timelines are guides that can vary if some activities are done at home or in other classes in addition to science.

Given your time constraints, it may not be possible to do all the activities shown on these timelines. If you need to remove activities, be careful not to remove any activities critical to the content of the unit. You may want to divide the activities among interdisciplinary members of your teaching team.

Page references in this chart refer to the student edition, except when Enrichments are suggested. The page references for Enrichments refer to this Teacher's Guide.

TABLE 1.2: Option 1: Three Week Timeline

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Introduce the unit Introduce Section 1 Assign **Mini Activity:** Relative Size of a Cell Complete **Mini Activity:** Using a Microscope to See Cells	Assign **Mini Activity:** Imagine a One-called Human Complete **Activity 1-1:** Why Are Cells Small?	**Mini Activity:** How changes in Surface Area and Volume Affect Cells with Different Shapes Review and Summarize Section 1	Introduce Section 2 Complete **Mini Activity:** Soap Bubbles Complete **Mini Activity:** A Drawing or Model of a Cell Membrane	Complete **Mini Activity:** What Does Each Part of a Cell Do?
Week 2	Assign **Activity 2-1:** Making a Cell Model (for a home project) Summarize and Review Section 2	Introduce Section 3 Complete **Activity 3-1:** Catalysts and Enzymes in Your Life	Complete **Mini Activity:** Transport of Nutrients: Exploring Diffusion	Complete **Activity 3-2:** Cell Division-Double or Nothing	Complete **Mini Activity:** Mitosis in Action Review and Summarize Section 3
Week 3	Introduce Section 4 Complete **Activity 4-1:** Removing DNA from Thymus Cells	Introduce and begin **Activity 4-2:** Building and Using a DNA Model Finish as homework	Discuss and explain protein synthesis: transcription and translation Assign **Mini Activity:** Coding (for homework)	Assign **Mini Activity:** Building a Protein Model (for homework) Introduce Section 5 Complete **Activity 5-1:** Cells Gone Awry	Unit Review Unit Assessment the following week

TABLE 1.3: Option 2: Five Week Timeline

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Introduce the unit Introduce Section 1 Assign **Mini Activity:** Relative Size of a Cell Complete **Mini Activity:** Using a Microscope to See Cells	Assign **Mini Activity:** Imagine a One-celled Human Introduce **Activity 1-1:** Why Are Cells Small?	Complete Activity 1-1	**Mini Activity:** How Changes in Surface Area and Volume Affect Cells with Different Shapes Review Section 1	Introduce Section 2 Complete **Mini Activity:** Soap Bubbles Complete **Mini Activity:** A Drawing or Model of a Cell Membrane

TABLE 1.3: (continued)

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 2	Complete **Mini Activity:** What Does Each Part of a Cell Do?	Begin **Activity 2-1:** Making a Cell Model, if it is being done in class	Continue work on Activity 2-1- due in one week Review Section 2	Quiz: on Sections 1 and 2	Introduce Section 3 Complete **Activity 3-1:** Catalysts and Enzymes in Your Life
Week 3	Complete **Mini Activity:** Transport of Nutrients: Exploring Diffusion	Complete **Enrichment 3-1:** Exploring Osmosis	Complete **Activity 3-2:** Cell Division-Double or Nothing Review Section 3	Complete **Mini Activity:** Mitosis in Action	Cell models due Section 3 Quiz
Week 4	Introduce Section 4 Complete **Activity 4-1:** Removing DNA from Thymus Cells	Introduce and begin **Activity 4-2:** Building and Using a DNA Model	Complete Activity 4-2. Discuss and explain protein synthesis, transcription, translation.	Assign **Mini Activity:** Coding	Assign **Mini Activity:** Building a Protein Model
Week 5	Complete **Enrichment 4-1:** Making Protein	Review and Assess Section 4 Introduce Section 5	Complete **Activity 5-1:** Cells Gone Awry	Unit Wrap-up/Review Unit	Unit Assessment

Safety for Teachers

- Always perform an experiment or demonstration on your own before allowing students to perform the activity. Look for possible hazards. Alert students to possible dangers. Safety instructions should be given each time an experiment is begun.
- Wear glasses and not contact lenses. Make sure you and your students wear safety goggles in the lab when performing any experiments.
- Do not tolerate horseplay or practical jokes of any kind.
- Do not allow students to perform any unauthorized experiments.
- Never use mouth suction in filling pipettes with chemical reagents.
- Never "force" glass tubing into rubber stoppers.
- Use equipment that is heat resistant.
- Set good safety examples when conducting demonstrations and experiments.
- Turn off all hot plates and open burners when they are not in use and when leaving the lab.
- When students are working with open flames, remind them to tie back long hair and to be aware of loose clothing in order to avoid contact with flames.
- Make sure you and your students know the location of and how to use fire extinguishers, eyewash fountains, safety showers, fire blankets, and first-aid kits.
- Students and student aides should be fully aware of potential hazards and know how to deal with accidents. Establish and educate students on first-aid procedures.
- Teach students the safety precautions regarding the use of electricity in everyday situations. Make sure students understand that the human body is a conductor of electricity. Never handle electrical equipment with

wet hands or when standing in damp areas. Never overload electrical circuits. Use 3-prong service outlets.
- Make sure that electrical equipment is properly grounded. A ground-fault circuit breaker is desirable for all laboratory AC circuits. A master switch to cut off electricity to all stations is desirable for all laboratory AC circuits.
- Make sure you and your students are familiar with how to leave the lab safely in an emergency. Be sure you know a safe exit route in the event of a fire or an explosion.

For Student Safety

Safety in the Classroom

- Wear safety goggles in the lab when performing any experiments. Tie back long hair and tuck in loose clothing while performing experiments, especially when working near or with an open flame.
- Never eat or drink anything while working in the science classroom. Only lab manuals, notebooks, and writing instruments should be in the work area.
- Do not taste any chemicals for any reason, including identification.
- Carefully dispose of waste materials as instructed by your teacher. Wash your hands thoroughly.
- Do not use cracked, chipped, or deeply scratched glassware, and never handle broken glass with your bare hands.
- Lubricate glass tubing and thermometers with water or glycerin before inserting them into a rubber stopper. Do not apply farce when inserting or removing a stopper from glassware while using a twisting motion.
- Allow hot glass to cool before touching it. Hot glass shows no visible signs of its temperature and can cause painful burns. Do not allow the open end of a heated test tube to be pointed toward another person.
- Do not use reflected sunlight for illuminating microscopes. Reflected sunlight can damage your eyes.
- Tell your teacher if you have any medical problems that may affect your safety in doing lab work. These problems may include allergies, asthma, sensitivity to certain chemicals, epilepsy, or any heart condition.
- Report all accidents and problems to your teacher immediately.

HANDLING DISSECTING INSTRUMENTS and PRESERVED SPECIMENS

- Preserved specimens showing signs of decay should not be used for lab observation or dissection. Alert your teacher to any problem with the specimen.
- Dissecting instruments, such as scissors and scalpels, are sharp. Use a cutting motion directed away from yourself and your lab partner.
- Be sure the specimen is pinned down firmly in a dissecting tray before starting a dissection.
- In most cases, very little force is necessary for making incisions. Excess force can damage delicate, preserved tissues.
- Do not touch your eyes while handling preserved specimens. First, wash your hands thoroughly with warm water and soap. Also wash your hands thoroughly with warm water and soap when you are finished with the dissection.

CHAPTER 2 Building Blocks of Life - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

2.1 Planning

Key Ideas

- Cells are the basic unit of life, each with a specific purpose.
- Cells, tissues, organs, and systems work together to form the structures and perform the functions of the human body.
- Cells are small, thus maintaining a vast surface area per unit volume to enhance cell efficiency.

Overview

The unit begins by inviting students to think about cells as the building blocks of life. Multicellular organisms are composed of different types of cells. These cells work together forming tissues, organs, and systems. Being small, cells maintain a vast surface area per unit volume to enhance efficiency. Students use a microscope to observe the similarities and differences among the cells that comprise different tissues. They also explore the effect an increase in the size of a cell has on the cell's efficiency.

Objectives

Students:

✓ identify different structural and functional characteristics of cells.

✓ distinguish between a cell, tissue, organ, and system.

✓ explain why cells are so small.

Vocabulary

cells, cell theory, connective tissue, epithelial tissue, muscle tissue, nervous tissue, organ, system, tissue

Student Materials

Activity 1-1: Why Are Cells Small?

- Resource
- Activity Report
- Plain paper for constructing a model of a cube; Scissors; Metric ruler; Clear tape

Teacher Materials

Activity 1-1: Why Are Cells Small?

- Activity Report Answer Key
- Demonstration cube models, 1 cm, 2 cm, 4 cm, and 8 cm on an edge

Advance Preparation

See Activity 1-1 in the Student Edition.

Activity 1-1: Why Are Cells Small?

- Gather student materials.
- Prepare demonstration cube models, 1 cm, 2 cm, 4 cm, and 8 cm on an edge. Models can be constructed from paper, as in the student activity procedure. More durable models can be cut from wood or made from modeling clay.
- Consider planning this activity with math teacher.

Interdisciplinary Connections

Math Students use formulas to calculate and graph the relationship between surface area and volume of cubes.

Students use mathematical formulas and discuss questions such as, "How is it that a fly getting out of a bathtub carries a film of water many times its own weight, whereas a person coming out of the bath carries away a film of water weighing about a pound?"

Art Use cube shapes of varying sizes to create a painting, drawing, or collage that shows relationships and perspectives of cube omparisons.

2.2 Using Building Blocks of Life – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Emphasize and discuss "What Cells Do" and "What Cells Look Like."

Introduce this section with the *Mini Activity: Using a Microscope to See Cells.*

Make sure students have experience using a microscope. If the microscope uses a mirror and natural light, make sure students know not to point the mirror directly at the sun.

Emphasize the relationship between cells, tissues, organs, and systems.

Discuss the *Mini Activity: Imagine a One-celled Human* as part of an introduction to the problem dealing with the relationship of the surface area to volume.

Complete *Activity 1-1: Why Are Cells Small?*

Assign *Mini Activity: How Changes in Surface Area and Volume Affect Cells with Different Shapes.*

Relate the big ideas of this section to one another by discussing answers to the Review Questions.

Select appropriate Projects, if time permits.

At the end of the section, refocus students' attention on the key ideas.

Mini-Activity

Using a Microscope to See Cells Students examine cells from different tissues under a microscope and compare their similarities and differences in appearance and shape.

Journal Writing

The existence of cells was first supported only after the discovery of the microscope. Do a library search to find out who invented the first microscopes and some of the scientists, besides Robert Hooke, who made important discoveries about cells.

Journal Writing

Many scientific discoveries have resulted from one person exploring something just because of curiosity. Have you ever watched an ant trail for a long time or observed the patterns on the surface of the moon? Describe in detail your observations of something you've "studied" simply because you were curious.

What Do You Think?

Consider the very different functions of blood cells, nerve cells, and muscle cells. (a) Do you think all these cells look alike? Why or why not? (b) Do you think one kind of cell could perform the functions of another? Why or why not?

Mini-Activity

Relative Size of a Cell Students list parts of the body in order of decreasing size to help them get an idea of the relative size of cells.

Journal Writing

Students list three of their favorite activities and explain in writing what kinds of cells they think are primarily involved in those activities.

Mini-Activity

Imagine a One-celled Human Students imagine how a one-celled human could function. They answer questions about how this cell would move, reproduce, exchange nutrients and wastes, and identify other problems that would result from its large size.

2.3 Activities and Answer Keys

Activity 1-1: Why Are Cells Small?

PLAN

Summary Students explore a model cell having the shape of a cube (cuboidal), such as some of the cells in the human throat (trachea) and kidney (the nephrons). They investigate the change in cell efficiency with increasing size, focusing on the relationship between surface area and volume. Students use two-dimensional drawings, a three-dimensional model, and mathematical calculations to make these comparisons. Finally, they relate their explorations of the surface area/volume ratio in the model cell to the importance of the microscopic size of human cells in the body.

Objectives

Students:

✓ construct paper models in the shape of cubes to represent cells.

✓ investigate the surface area-to-volume ratios of model, cube-shaped cells.

✓ explain the relationship between surface area and volume of a cube as its size changes.

✓ explain the importance of the microscopic size of cells in the body.

Student Materials

- Resource
- Activity Report
- Plain paper for constructing a model of a cube
- Scissors
- Metric ruler
- Clear tape

Teacher Materials

- Activity Report Answer Key
- Demonstration cube models, 1 cm, 2 cm, 4 cm, and 8 cm on an edge

Advance Preparation

Gather student materials.

Prepare demonstration cube models, 1 cm, 2 cm, 4 cm, and 8 cm on an edge. Models can be constructed from paper, as in the student activity procedure. More durable models can be cut from wood or made from modeling clay.

Consider planning this activity with the math teacher.

Estimated Time One to two periods

Interdisciplinary Connections

Math Complete math calculations and graphing on changes in surface area and volume.

Art Use cube shapes of varying sizes to create a painting, drawing, or collage showing relationships and perspectives of cube comparisons.

Prerequisites and Background Information

Students need basic math skills of addition, subtraction, multiplication, and division. They also need to be familiar with metric units for measuring area and volume.

IMPLEMENT

Introduce Activity 1-1 by reviewing the formula and calculations for surface area and volume of a cube, and how to calculate the surface area to volume *ratio*.

Helpful Hints

- Calculator use is optional.
- Use metric graph paper.
- Students can build additional models of different sizes for comparison.

Steps 1-3 Show students sample models.

Have students verify the formula for surface area and volume of a cube by counting the squares in the two-dimensional (2-D) cube patterns. Have students graph the relationship between surface area and volume for each cube. These graphs can be done separately or superimposed.

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ construct paper models in the shape of cubes to represent cells.

✓ explain the changes in the surface area-to-volume ratios as the cube size increases.

✓ explain the importance of small size to the efficiency of the cell.

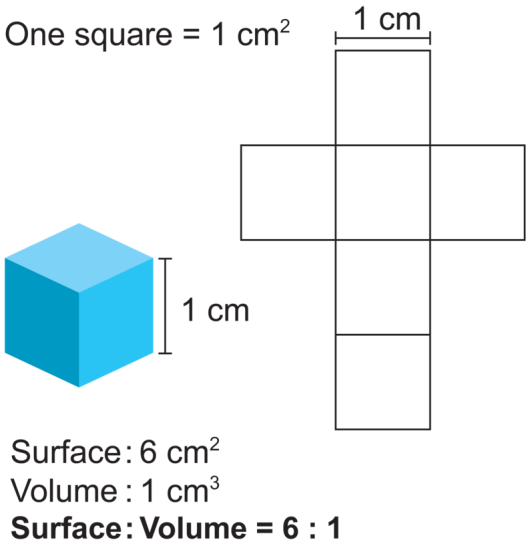
Activity 1-1: Why Are Cells Small? – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Part A

What are the surface area and the volume for a cube-shaped cell?

Look at the illustration of a cube 1 cm on an edge. Use this information to answer the questions below.



1. (a) What is the area of one side?
   (b) Do all sides have the same area?
   (c) How many sides does the cube have?
2. Calculate the surface area of a cube 1 cm on a side using the formula for Area of a Cube: Area = Length × Width × 6 sides . Remember to include the correct units of measurement. Check your answer on the table below.
3. Now calculate the volume of this cube using the formula for Volume of a Cube: Volume = Length × Width × Height . Again, remember to include the correct units of measurement. Check your answer on the table below.
4. Which is the greater number, the surface area or the volume? Show this relationship in a surface/volume ratio. Check your answers with those in the table below.

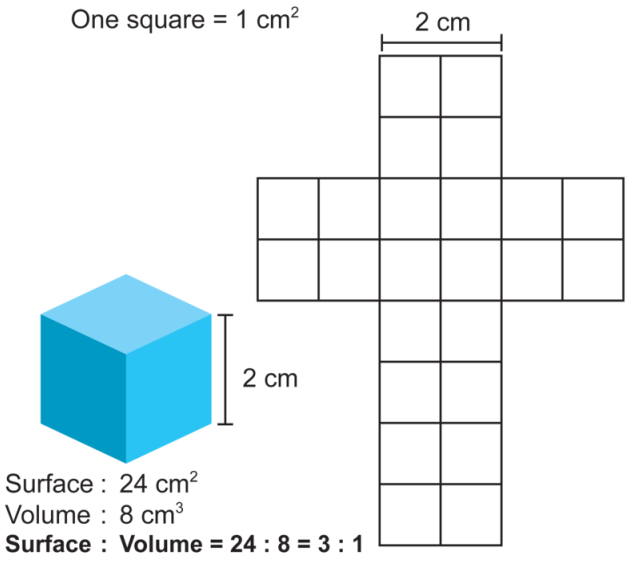
TABLE 2.1:

Length of side (cm)	**Surface Area** $(A = L \times W \times 6)$	**Volume** $(V = L \times W \times H)$	**Surface/Volume**
1 cm	6 cm^2	1 cm^3	$\frac{6}{1}$ or 6:1

Part B

Build a model to show what happens to a cube-shaped cell when it doubles in size.

Look at the illustration for a cube 2 cm on an edge. Use the Resource to cut out this pattern. Cut out this pattern. Fold your pattern correctly to make a three-dimensional (3-D) model of a cube.



Use your model of a cube 2 cm on an edge to answer the following questions.

1. (a) What is the area of one side?
   (b) Do all sides have the same area?
   (c) How many sides does the cube have?
2. Calculate the surface area of a cube 2 cm on a side using the formula for Area of a Cube: Area = Length × Width × 6 sides . Remember to include the correct units of measurement.
3. Now calculate the volume of this 2-cm cube using the formula for Volume of a Cube: Volume = Length × Width × Height . Again, remember to include the correct units of measurement.
4. Show the relationship of surface area to volume in a surface/volume ratio.
5. Record your calculations and complete the following table for cubes 4 cm and 8 cm on a side.

TABLE 2.2:

Length of side (cm)	**Surface Area** $(A = L \times W \times 6)$	**Volume** $(V = L \times W \times H)$	**Surface/Volume**
1 cm	6 cm^2	1 cm^3	$\frac{6}{1}$ or 6:1
2 cm			
4 cm			
8 cm			

Part C

What happens to the relationship between surface area and volume when a cube-shaped cell doubles in size?

1. Look carefully at the surface/volume changes in your table from part B.
   (a) When the size of a cell doubles from 1 cm to 2 cm on a side, how many times greater is the surface area?
   (b) How many times greater is the volume?
   (c) Which increased more, surface area or volume? Show your work.
2. For further exploration, make a graph to show these relationships. (Hint: plot length of one cube side on the horizontal axis, and surface area and/or volume on the vertical axis.)
3. Imagine that the cubes represent cells of different sizes and the surface of the cubes represents the cell membrane. Which cube size would be most efficient in carrying out essential cell activities? Give reasons for your answer.

4. What could a cell do to increase the surface/volume ratio? Explain, using your calculations from this activity to support your answer.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

When animals use the energy they get from food, they lose a lot of that energy as heat radiating from the surface of their bodies. Explain why small animals, such as a mouse or a hummingbird, have to spend most of their time eating.

Mini-Activity

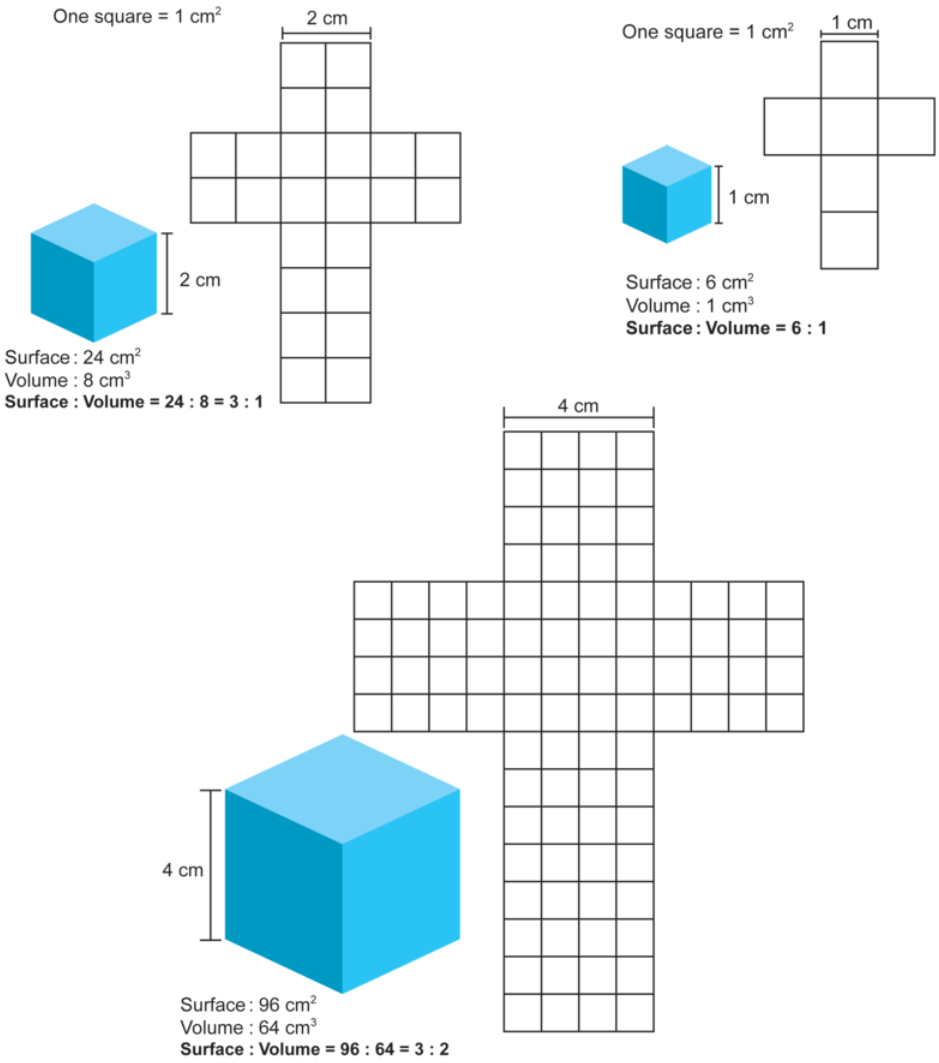
How Changes in Surface Area and Volume Affect Cells with Different Shapes Students use a spherical-shaped cell to explore the surface area-to-volume ratio as cells increase in size.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Describe four characteristics or functions of cells.
2. Describe the cell theory in your own words.
3. What is the relationship between a cell, tissue, organ, and system? Include examples.
4. Why are cells so small?
5. Why is homeostasis important to cells?

Activity 1-1 Resource: Why Are Cells Small? (Student Reproducible)

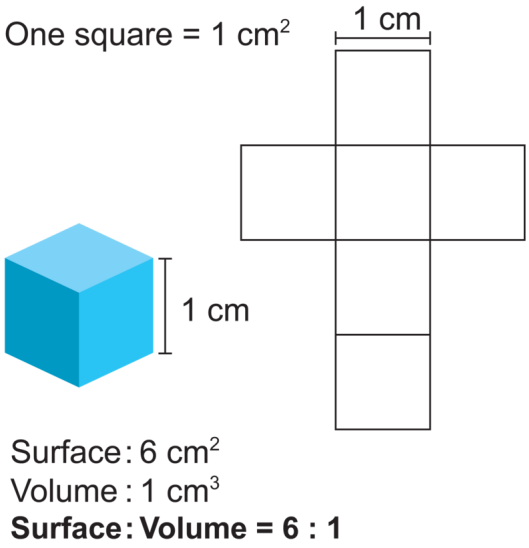


Activity 1-1 Report: Why Are Cells Small? (Student Reproducible)

Part A

What are the surface area and the volume for a cube-shaped cell?

Look at the illustration of a cube 1 cm on an edge. Use this information to answer the questions below.



1. a. What is the area of one side of the cube? _____

b. Do all sides have the same area? _____

c. How many sides does the cube have? _____

2. Calculate the surface area of a cube 1 cm on a side using the formula for Area of a Cube: Area = Length × Width × 6 sides . Remember to include the correct units of measurement. Check your answer on the table below.

3. Now calculate the volume of this cube using the formula for Volume of a Cube: Volume = Length × Width × Height . Again, remember to include the correct units of measurement. Check your answer on the table below.

4. Which is the greater number, the surface area or the volume? Show this relationship in a surface area/volume ratio. Check your answers with those in the table below.

TABLE 2.3:

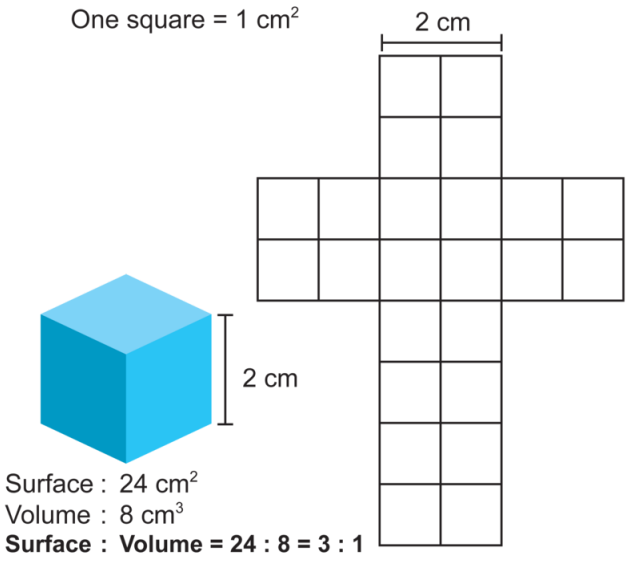
Length of side (cm)	**Surface Area** $(A = L \times W \times 6)$	**Volume** $(V = L \times W \times H)$	**Surface/Volume**
1 cm	6 cm^2	1 cm^3	$\frac{6}{1}$ or 6:1

Part B

Build a model to show what happens to a cube-shaped cell when it doubles in size.

Look at the illustration for a cube 2 cm on an edge. Use the Resource to cut out this pattern. Fold your pattern correctly to make a three-dimensional (3-D) model of a cube.

Use your model of a cube 2 cm on an edge to answer the following questions.



1. a. What is the area of one side?

b. Do all sides have the same area?

c. How many sides does the cube have?

2. Calculate the surface area of a cube 2 cm on a side using the formula for Area of a Cube: Area = Length × Width × 6 sides . Remember to include the correct units of measurement.

3. Now calculate the volume of this 2-cm cube using the formula for Volume of a Cube: Volume = Length × Width × Height . Again, remember to include the correct units of measurement.

4. Show the relationship of surface area to volume in a surface area/volume ratio.

5. Record your calculations and complete the following table for cubes 4 cm and 8 cm on a side.

TABLE 2.4:

Length of side (cm)	**Surface Area** $(A = L \times W \times 6)$	**Volume** $(V = L \times W \times H)$	**Surface Volume**
1 cm	6 cm^2	1 cm^3	$\frac{6}{1}$ or 6:1
2 cm			
4 cm			
8 cm			

Part C

What happens to the relationship between surface area and volume when a cube-shaped cell doubles in size?

1. Look carefully at the surface/volume changes in your table from Part B.

a. When the size of a cell doubles from 1 cm to 2 cm on a side, how many times greater is the surface area?

b. How many times greater is the volume?

c. Which increased more, surface area or volume? Show your work.

2. For further exploration, make a graph to show these relationships. (Hint: plot length of one cube side on the horizontal axis and surface area and/or volume on the vertical axis.)

3. Imagine that the cubes represent cells of different sizes and the surface of the cubes represents the cell membrane. Which cube size would be most efficient in carrying out essential cell activities? Give reasons for your answer.

4. What could a cell do to increase its surface area/volume ratio? Explain, using your calculations from this activity to support your answer.

CHAPTER 3 Cell Parts and Their Functions - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

3.1 Planning

Key Ideas

- Cell parts and organelles are responsible for the specific functions of eukaryotic cells.
- The cell membrane is composed of a bilayer of lipids and proteins arranged in an orderly manner.
- The substances that go into or out of a cell are determined by the structure of the cell membrane.

Overview

Building from the general introduction to cells and their functions in the previous section, students explore the major parts and organelles of a eukaryotic cell. They investigate the composition of the cell membrane in detail and its function in controlling what substances move into and out of the cell. Students design and build a 3-D model of a eukaryotic cell. They also simulate the movement of proteins embedded within the cell membrane by observing large soap bubbles.

Objectives

Students:

✓ identify the location and function of the major organelles of a cell.

✓ describe the unique characteristics of the cell membrane including the arrangement of the proteins and lipids.

✓ determine the relationship among mitochondria, sugar, and ATP.

✓ explain how ribosomes, the endoplasmic reticulum, and the Golgi apparatus are related to the production and transport of proteins.

Vocabulary

adenosine triphosphate (ATP), cell membrane, chromosomes, cytoplasm, DNA (deoxyribonucleic acid), endoplasmic reticulum, Golgi apparatus, mitochondria, nucleus, organelles, ribosomes

Student Materials

Activity 2-1: Making a Cell Model

- Activity Report

- Determined by each team, with teacher approval

Teacher Materials

Activity 2-1: Making a Cell Model

- Activity Report Answer Key
- Be sure to guide students to select materials that will not spoil.
- Cell parts or organelles can be represented by a variety of materials, such uncooked pasta; dried fruit; plaster of paris or clay models
- Possible materials for the cell membrane include a shoe box, plastic jug, or plastic bag
- Cell models, diagrams, and/or charts

Advance Preparation

See Activity 2-1 in the Student Edition.

Activity 2-1: Making a Cell Model

- Allow ample time for students to collect their own materials and to add other materials as needed for their model cell.
- Plan ahead for storage of completed cell models.

Interdisciplinary Connection

Art Students make models of different cell types (nerve cell, muscle cell, etc.).

3.2 Using Cell Parts and Their Functions – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Begin this section by doing the *Mini Activity: Soap Bubbles* in class.

Assign *Mini Activity: A Drawing or Model of a Cell Membrane* and discuss the role of models in science.

Complete the *Apply Your Knowledge* related to Passage through a Cell Membrane.

Assign *Journal Writing* that asks students to think of a place or building that allows only certain people to enter or leave, such as a ride at an amusement park or a building with security guards at the doors. Describe how that place regulates who can come and go. What criteria does it use? How does this compare to a cell membrane?

As you begin a discussion of the cell parts and their function, assign the *Mini Activity: What Does Each Part of a Cell Do?* so that students can add to the information regarding each structure as they go through this section, and ultimately the entire unit.

Point out and explain that chromosomes are parts of cells, but not an organelle.

Conclude this section by assigning *Activity 2-1: Making a Cell Model.*

Emphasize the big ideas of this section by discussing answers to the Review Questions.

Select appropriate Projects, if time permits.

At the end of the section, refocus students' attention on the key ideas.

Mini-Activity

A Drawing or Model of a Cell Membrane Students draw a picture or make a model of a cell membrane to show how lipids are arranged.

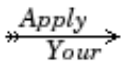
Mini-Activity

Soap Bubbles Students use soap bubbles to simulate the movement of molecules within the cell membrane.

Journal Writing

Think of a place or building that allows only certain people to enter or leave, such as a ride at an amusement park or a building with security guards at the doors. Describe how that place regulates who can come and go. What criteria does it use? How does this compare to a cell membrane?

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**



Study the table in Figure 2.6. Then answer the following questions.

1. **Substance W is smaller than 5 nanometers (nm).**
2. **Substance X is larger than 1 nm but smaller than 3 nm.**
3. **Substance Y is larger than 3 nm but smaller than 5 nm.**
4. **Substance Z is larger than 5 nm.**
5. **If membranes with different pore sizes were available how could you determine the exact size of substance X? Use the different membranes to try each substance.**

Mini-Activity

What Does Each Part of a Cell Do? Students keep a record of what each organelle or part of the cell does.

What Do You Think?

Why do you think it would be an advantage for a cell to have a membrane-bound nucleus?

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

For each of the cell organelles or parts listed above, explain how each one contributes to the overall internal balance (homeostasis) of the cell to keep it functioning smoothly.

3.3 Activities and Answer Keys

Activity 2-1: Making a Cell Model

PLAN

Summary Students begin by drawing a picture of a cell and labeling its parts. They use their drawings as a blueprint to design and construct a 3-D model of a cell. Students explain the function of each part of the cell model.

Objectives

Students:

✓ draw an accurate picture and identify the parts of a cell.

✓ design and construct a three-dimensional model of a cell.

✓ explain the function of each part of their cell model.

Student Materials

- Activity Report
- Determined by each team, with teacher approval

Teacher Materials

- Activity Report Answer Key
- Be sure to guide students to select materials that will not spoil.
- Cell parts or organelles can be represented by a variety of materials, such uncooked pasta; dried fruit; plaster of paris or clay models.
- Possible materials for the cell membrane include a shoe box, plastic jug, or plastic bag.
- Cell models, diagrams, and/or charts

Advance Preparation Allow ample time for students to collect their own model materials and to add other materials as needed. Plan ahead for storage of completed cell models.

Estimated Time One class period

Interdisciplinary Connection

Art Invite the art teacher to help students select and collect materials for their models. Completed models can be displayed in the art class or in the art display area for the school.

Prerequisites and Background

Students need to be familiar with eukaryotic cell parts and their functions.

IMPLEMENT

Steps 1-5 This activity can be assigned as an individual project to be completed at home or as a class activity for groups or individual students. Make sure students get your approval of the materials they select to use in building their model cells.

Extend Activity 2-1 by having students create a board game based on the cell structures and functions.

ASSESS

Use the designs of the cell models and the written answers on the Activity Report to assess if students can

✓ design and build an accurate 3-D model of a cell.

✓ identify the parts of a cell.

✓ explain the function of each part of the cell model.

Activity 2-1: Making a Cell Model – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Draw and label a picture of the cell that you are going to make.
2. List the materials that you have selected to use to make your model of the cell.
3. What is the function of each of the following parts of a cell?

   (a) cell membrane:
   (b) cytoplasm:
   (c) nucleus:
   (d) chromosomes:
   (e) mitochondria:
   (f) ribosomes:
   (g) endoplasmic reticulum:
   (h) Golgi apparatus:

4. If you were going to make another model of a cell what would you do differently? Explain why.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the primary function of the cell membrane? Describe three structural characteristics of the cell membrane.
2. What is the difference between a eukaryotic and a prokaryotic cell? Include examples of eukaryotes and prokaryotes.
3. What is the functional relationship among mitochondria, sugar, and ATP?
4. How are ribosomes, the endoplasmic reticulum, and the Golgi apparatus involved in the production and transport of proteins?

Activity 2-1 Report: Making a Cell Model (Student Reproducible)

1. Draw and label a picture of the cell that you are going to make.
2. List the materials that you have selected to use to make your model cell.
3. What is the function of each of the following parts of a cell?

a. cell membrane

b. cytoplasm

c. nucleus

d. chromosomes

e. mitochondria

f. ribosomes

g. endoplasmic reticulum

h. Golgi apparatus

4. If you were going to make another model of a cell, what would you do differently? Explain why.

CHAPTER 4

Cell Activities - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

4.1 Planning

Key Ideas

- The life of a cell depends on the activities that take place within it and also on the environment surrounding it.
- Enzymes help chemical reactions take place inside the cell. They help build products, make copies of molecules, and carry out cell functions efficiently.
- The selectively permeable cell membrane allows water to pass through it, but not large molecules dissolved in water.
- Passive and active transport are the processes by which substances move in and out of the cell.
- Cellular respiration requires oxygen and produces ATP, the energy needed for the cell to do its work.
- Cell division is one of the important events of the cell cycle.

Overview

Following the study of the cell parts and their functions in the previous section, students explore the important cell activities of cellular respiration, the transport of molecules, and cell division. Students investigate enzymes and explore factors that affect their activity. They also simulate each stage of mitosis and meiosis using pipe cleaners to represent chromosomes.

Objectives

Students:

✓ identify and explain the important functions of enzymes.

✓ explain the processes of osmosis and diffusion.

✓ simulate the processes of mitosis and meiosis.

Vocabulary

active transport, cell cycle, cellular respiration, diffusion, diploid, enzymes, gamete cells, haploid, meiosis, mitosis, osmosis, passive transport, somatic cells

Student Materials

Activity 3-1: Catalysts and Enzymes in Your Life

- Data Table
- Activity Report
- Goggles for each team member
- Test tubes (5 per team); Test tube rack; Test tube holder; Marking pen/pencil for test tubes; Graduated cylinder; Forceps; Stirring rod; Hydrogen peroxide (H_2O_2 -3%); Sand; Manganese dioxide (MnO_2) ; Wood splints; Paper towels; Liver cell samples (cooked and uncooked)

Activity 3-2: Cell Division-Double or Nothing

- Resources 1 and 2
- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible); Large paper plates (2); Eight pipe cleaners (2 long of color A, 2 long of color B, 2 short of color A, and 2 short of color B)

Teacher Materials

Activity 3-1: Catalysts and Enzymes in Your Life

- Activity Report Answer Key
- Goggles
- Data Table (Optional: to be used if students do not design their own or as a model); Extra test tubes, splints, hydrogen peroxide and paper towels should be available; Liver cell samples (uncooked, cooked, and uncooked soaked in vinegar); Test tube brushes at sinks; Wooden splints and matches, for demonstration to identify gas bubbles as oxygen

Activity 3-2: Cell Division-Double or Nothing

- Activity Report Answer Key
- Additional student supplies
- Resources 1 and 2 (Optional)

Advance Preparation

See Activities 3-1 and 3-2 in the Student Edition.

Activity 3-1: Catalysts and Enzymes in Your Life

- Review student pages relating to enzymes.
- Gather and prepare necessary lab materials.

- Purchase fresh liver from a local butcher preferably one or two days before the activity. Keep refrigerated until use.
- Prepare three liver samples, one cubic centimeter in size, for each team.
- Each team needs
  - one piece of fresh liver, best prepared on the day of the activity.
  - one piece of fresh liver that has been thoroughly cooked for 5-10 minutes in a microwave. It is recommended that the samples be placed in a small amount of water and covered before microwaving, in order to prevent drying out. Cooked samples can be stored overnight in a refrigerator.
  - one piece of fresh liver that has been soaked overnight in vinegar.
- If time is limited, copy the Data Table for student use.

Activity 3-2: Cell Division-Double or Nothing

- Collect student materials.
- Make copies of Resources 1 and 2 if you plan to do the Optional extension of this activity.

Interdisciplinary Connection

Art Students make models, pictures, or diagrams to illustrate how enzymes work.

Enrichment Activity

Enrichment 3-1: Exploring Osmosis

4.2 Using Cell Activities – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Begin this section with a discussion of enzymes and their roles in facilitating chemical reactions in the cell, building products, making copies of molecules and carrying out cell functions.

Complete *Activity 3-1: Catalysts and Enzymes in Your Life.*

Discuss *Mini Activity: Transport of Nutrients: Exploring Diffusion.* Have students compare and contrast the processes of passive and active transport.

Emphasize how a selectively permeable membrane functions; consider completing *Enrichment 3-1: Exploring Osmosis.*

Point out what occurs during cellular respiration.

Emphasize the difference between a somatic cell and a gamete cell.

Complete *Activity 3-2: Cell Division-Double or Nothing* with emphasis on cell division as one of the important events of the cell cycle.

Have students share their completed *Mini Activity: Mitosis in Action.*

Emphasize the big ideas of this section by discussing answers to the Review Questions.

Select appropriate Projects and other activities, if time permits.

At the end of the section, refocus students' attention on the key ideas.

4.3 Activities and Answer Keys

Activity 3-1: Catalysts and Enzymes in Your Life

PLAN

Summary Students conduct experiments to distinguish between a catalyst (manganese dioxide, MnO_2) and an enzyme (catalase). They investigate the action of the enzyme catalase on hydrogen peroxide (H_2O_2) and explore factors that influence enzyme activity.

Objectives

Students:

✓ distinguish between a catalyst (manganese dioxide, MnO_2) and an enzyme (catalase).

✓ investigate the action of the enzyme catalase on hydrogen peroxide.

✓ explore factors that influence enzyme activity.

✓ explain the role of enzymes in maintaining homeostasis in cells.

Student Materials

- Data Table
- Activity Report
- Test tubes (5 per team); Test tube rack; Test tube holder; Marking pen/pencil for test tubes; Graduated cylinder; Forceps; Stirring rod; Hydrogen peroxide (H_2O_2 -3%); Sand; Manganese dioxide (MnO_2) ; Wood splints; Paper towels; Goggles for each team member; Liver cell samples (cooked and uncooked)

Teacher Materials

- Activity Report Answer Key
- Data Table (Optional: to be used if students do not design their own or as a model)
- Extra test tubes, splints, hydrogen peroxide, and paper towels should be available.
- Liver cell samples (uncooked, cooked, and uncooked soaked in vinegar)
- Test tube brushes at sinks
- Wooden splints and matches, for demonstration to identify gas bubbles as oxygen

Advance Preparation

Review student pages relating to enzymes.

Gather and prepare necessary lab materials.

Purchase fresh liver from a local butcher preferably one or two days before the activity. Keep refrigerated until use.

Prepare three liver samples, one cubic centimeter in size, for each team.

Each team needs

- one piece of fresh liver, best prepared on the day of the activity.

- one piece of fresh liver that has been thoroughly cooked for 5-10 minutes in a microwave. It is recommended that the samples be placed in a small amount of water and covered before microwaving, in order to prevent drying out. Cooked samples can be stored overnight in a refrigerator.
- one piece of fresh liver that has been soaked overnight in vinegar.

If time is limited, copy Data Table for student use.

Estimated Time One class period

Interdisciplinary Connection

Art Draw a picture or make a model to illustrate how enzymes work.

Prerequisites and Background

Students need some knowledge of how catalysts and enzymes work. They also need to know how to construct a data table and use a graduated cylinder.

IMPLEMENT

Introduce Activity 3-1 by discussing lab safety rules. Remind students to wear safety goggles as they do this activity. Model the use of goggles.

Step 1 You can choose to have students design their own data table. Or you can copy the Data Table on TE page 35 for students to use.

Step 2 For each team, set out lab materials in trays in an area easily accessible to all students. Glass containers can be substituted for test tubes. The containers must have a minimum height of $2''$ to allow for the effervescence of oxygen bubbles. Glass baby food jars could be used.

Steps 3-12 Safety Caution: Be sure students keep hydrogen peroxide capped and stored away from fire and heat.

This lab activity can be used in a variety of ways. If you have time, students can complete the entire lab in their groups. This activity can be done in one period or done by section during successive class periods.

If time is limited, consider using Part A as a demonstration and have students complete Part B in lab groups. Another approach is to have lab groups each complete a different section of the experiments and then pool results to share with the class.

Helpful Hints

Students should design their own data tables, if time permits. One example of a student data table is included.

Clean up directions should emphasize the importance of wrapping any pieces of used liver or other solid materials in paper towels for disposal.

Set up stations for washing and cleaning equipment at the end of each class. Include test tube brushes.

For further explorations, invite students to design experiments exploring other factors influencing enzyme activity, such an extreme drop in temperature caused by freezing the liver. They also could investigate what happens when the liver has been subjected to a high pH (alkaline or basic condition).

Extend Activity 3-1 by demonstrating how to identify the released gas as oxygen. Be sure you have a safe area with a water supply for this demonstration. Discuss lab safety rules and model safe lab techniques, making sure to wear goggles during the demonstration.

To carry out this demonstration, use the following procedure.

- Put 5-10 ml hydrogen peroxide into a clean test tube. Then add a small amount of manganese dioxide. You should see many bubbles given off.

- Now light a wooden splint with a match and then blowout the fire. While the splint is still glowing, place it into the test tube near the surface of the bubbles.
- The splint should burst into flame because of the rich oxygen supply produced by the decomposing of hydrogen peroxide. Be careful not to place the glowing splint into the liquid or it will go out.
- You may want to repeat this demonstration substituting uncooked liver in place of manganese dioxide.

ASSESS

Use the completion of the activity, the written answers on the Activity Report, and the student presentation to assess if students can

✓ distinguish between a catalyst (manganese dioxide, MnO_2) and an enzyme (catalase).

✓ describe the action of the enzyme catalase on hydrogen peroxide (H_2O_2)

✓ distinguish factors that influence enzyme activity (high temperature due to prolonged heating) and pH (prolonged exposure to vinegar, an acid).

✓ explain the importance of enzymes in maintaining homeostasis in cells.

Activity 3-1: Catalysts and Enzymes in Your Life – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

Part A

How are a catalyst and an enzyme similar and how are they different?

1. What is the purpose of using sand in test tube #1?
2. Manganese dioxide is a nonprotein substance found in nature, but not produced by living cells. Manganese dioxide is an example of a catalyst. Based upon your observations, what is the function of manganese dioxide in test tube #2?
3. Describe one difference between the catalyst manganese dioxide and the enzyme catalase.
4. Liver (test tube #3) is composed of cells that produce the enzyme called catalase. How does the action of the enzyme catalase from liver compare with the action of manganese dioxide in test tube #2?
5. Describe another difference between the catalyst manganese dioxide (test tube #2) and the enzyme catalase (test tube #3).

Part B

What influences enzyme action?

6. How do the results of test tube #3 (control) compare with those from test tube #4? Use your observations to explain any difference.
7. How do the results of test tube #3 (control) compare with those from test tube #5? Use your observations to explain any difference.
8. As a summary of your knowledge of enzymes, explain:
    - what an enzyme is;
    - where enzymes are produced;
    - what an enzyme does;
    - why enzymes are important in cells and in our body; and

- what some factors are that influence enzyme action.

You may present this information in the form of a poster, a computer presentation, or another form of your choice.

Activity 3-1: Catalysts and Enzymes in Your Life Data Table Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

TABLE 4.1:

Sample	Observations
1.	

Mini-Activity

Transport of Nutrients: Exploring Diffusion Students design an activity to explore diffusion using items such as perfume, deodorizer spray, and water and food coloring.

What Do You Think?

Considering what happens to red blood cells in different environments, describe what you think would happen if you moved a single-celled organism from its normal freshwater pond to a saltwater environment. What about moving a saltwater single-celled organism to fresh water? Explain.

Journal Writing

You and your best friend are in a canoe on a river. Describe the effort you put in to get the boat to move with the current. Suddenly you realize you forgot something on the shore, so you turn around and paddle upstream. Describe your efforts to move against the current. How is this scenario like active and passive transport? Explain.

What Do You Think?

Why do you think it is so important for living things to reproduce and pass on their genetic material? Why is this "the purpose of life"?

Activity 3-2: Cell Division-Double or Nothing

PLAN

Summary Students simulate the process of mitosis using pipe cleaners to represent chromosomes. They compare the cell before and after division to learn that no genetic information is lost during cell division and that each new cell has the same number of chromosomes.

Objectives

Students

✓ simulate each stage of mitosis using pipe cleaners to represent chromosomes.

✓ identify and explain the sequence of events in mitosis.

✓ determine that no genetic information is lost during cell division and each new cell has the same number of chromosomes.

Student Materials

- Resources 1 and 2
- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible)
- Large paper plates (2)
- Eight pipe cleaners (2 long of color A, 2 long of color B, 2 short of color A, and 2 short of color B)

Teacher Materials

- Activity Report Answer Key
- Additional student supplies
- Resources 1 and 2 (Optional)

Advance Preparation

- Collect student materials.
- Make copies of Resources 1 and 2 if you plan to do the Optional Activity.

Estimated Time One class period

Interdisciplinary Connection

Art Students can illustrate the processes of mitosis on a poster or in a collage.

Prerequisites and Background

Students need to be familiar with the parts of the cell and the process of mitotic cell division.

IMPLEMENT

Steps 1-8 Have students work in pairs. Give one set of student materials to each pair. However, each student should complete his or her own Activity Report.

Monitor student progress to check students' knowledge after each simulated stage of mitosis.

Optional Activity To provide an optional (but recommended) activity to reinforce concepts presented in this activity, use Resource 1 (student procedure) and Resource 2 (chromosome cards). If you choose to do this optional activity, here are some helpful ideas to use.

1. Consider laminating the chromosome cards before students use them.

2. Encourage students to enhance their demonstrations of chromosome card movements with verbal and/or written explanations.

3. Students can summarize what they learned by completing one of the following additional creative activities to share with classmates. They can create a

- poster.

- book, with illustrations.
- poem.
- computer simulation.

Helpful Hints

- Check student knowledge after each simulated stage of mitosis.
- The first teams to demonstrate the correct sequence of mitotic stages can act as "Teacher Assistants" to help other teams.

ASSESS

Use the completion of the activity and written responses on the Activity Report to assess if students can

✓ simulate each stage of mitosis.

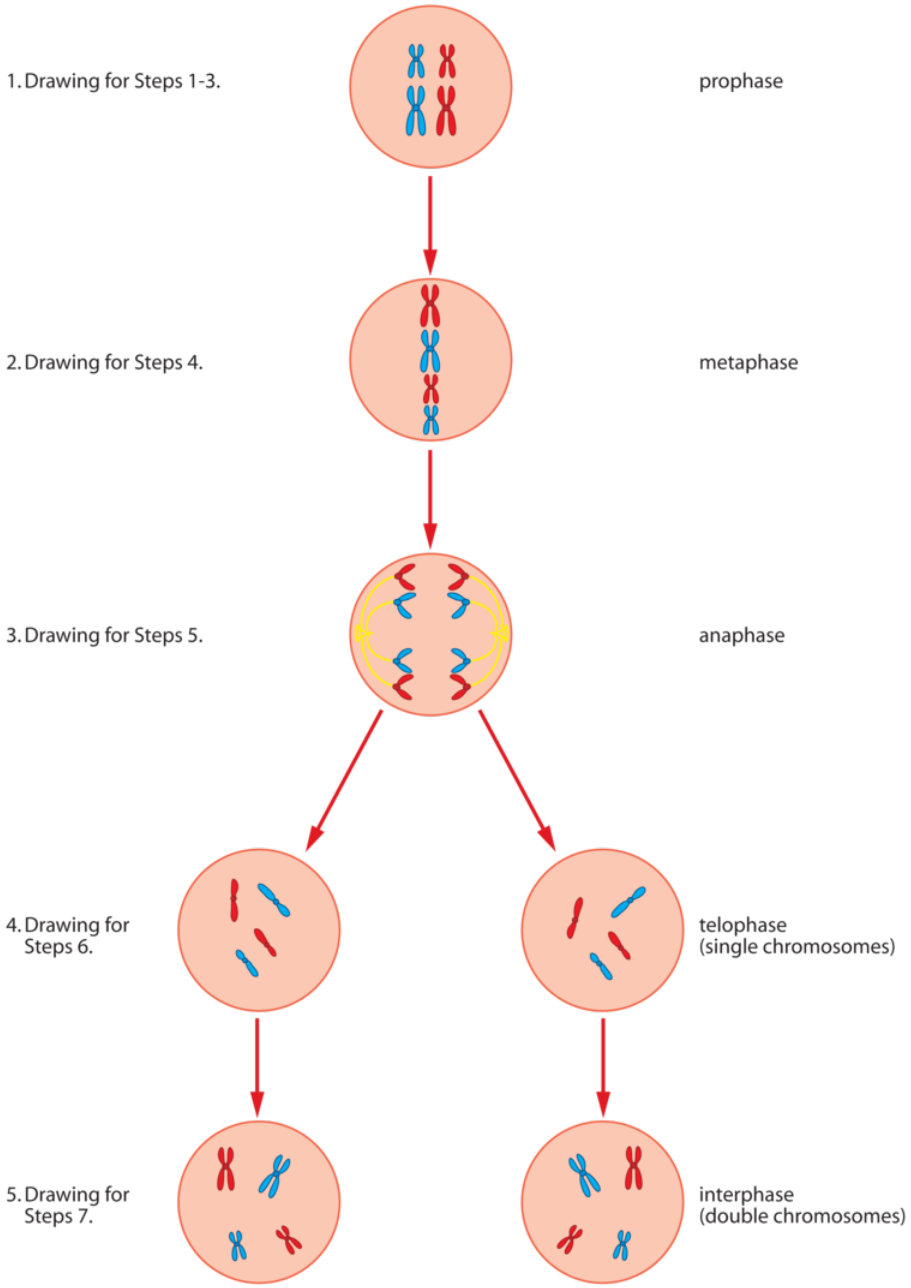
✓ identify the sequence of events in mitosis.

✓ determine that no genetic information is lost during cell division and each new cell has the same number of chromosomes.

Activity 3-2: Cell Division-Double or Nothing – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Compare the chromosome number of the parent cell with that of each of the two daughter cells.
2. Compare the genetic information of the parent cell with that of each of the two daughter cells with single chromosomes.
3. What is the importance of mitosis to the organism?
4. You have 46 chromosomes in each of your somatic cells. If you cut your arm, how many chromosomes would be in each newly formed skin cell?
5. Pretend that you are a double chromosome in the nucleus of a finger cell. Describe in a paragraph your experience going through cell division becoming a new finger cell. Diagram as you did on your Activity Report.



Mini-Activity

Mitosis in Action

Students create a cartoon, poster, story book, poem, dance, or song or build a model to summarize what they have learned about mitosis.

What Do You Think?

Some single-celled organisms such as an *amoeba* don't use gamete cells produced by meiosis. Single-celled organisms reproduce through mitosis only. Why might this process be a good way to pass on their genetic material to their offspring? What might be some problems with this method of reproduction?

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What are enzymes and why are they important to the cell?
2. What are the roles of osmosis and diffusion in the cell?
3. Why do cells divide?
4. How are mitosis and meiosis similar? How are they different?

Activity 3-1 Data Table: Catalysts and Enzymes in Your Life (Student Reproducible)

TABLE 4.2:

Sample	Observations
#1.	
#2.	
#3.	
#4.	
#5.	

Activity 3-1 Report: Catalysts and Enzymes in Your Life (Student Reproducible)

Part A

How are a catalyst and an enzyme similar and how are they different?

1. What is the purpose of using sand in test tube #1?

2. Manganese dioxide is a nonprotein substance found in nature, but not produced by living cells. Manganese dioxide is an example of a catalyst. Based upon your observations, what is the function of manganese dioxide in test tube #2?

3. Describe one difference between the catalyst manganese dioxide and the enzyme catalase.

4. Liver (test tube #3) is composed of cells that produce an enzyme called catalase. How does the action of the enzyme catalase from liver compare with the action of manganese dioxide in test tube #2?

5. Describe another difference between the catalyst manganese dioxide (test tube #2) and the enzyme catalase (test tube #3).

Part B

What influences enzyme action?

6. How do the results of test tube #3 (control) compare with those from test tube #4? Use your observations to explain any difference.

7. How do the results of test tube #3 (control) compare with those from test tube #5? Use your observations to explain any difference.

8. As a summary of your knowledge of enzymes, explain

- what an enzyme is;
- where enzymes are produced;
- what an enzyme does;
- why enzymes are important in cells and in our body; and
- what some factors are that influence enzyme action.

You may present this information in the form of a poster, a computer presentation, or another form of your choice.

Activity 3-2 Resource 1: Cell Division-Double or Nothing (Student Reproducible)

Introduction

How much do you know about mitosis? Can you demonstrate your knowledge of mitosis to a friend? Using the instructions below and the chromosome cards, work with a partner to simulate the sequence of events that occur during mitosis. Be sure that you demonstrate events before and after replication of DNA, the sorting of chromosomes, and the cell division resulting in two daughter cells.

Materials

- Resource 2 (chromosome cards)
- Activity Report
- Scissors
- Tape
- Large piece of butcher paper to represent the cell

Procedure

Step 1 Put your initials on the back of each card in your deck of 46 cards. This deck represents the diploid number of chromosomes.

Step 2 Place your chromosomes in numerical sequence from autosomal chromosome #1 through #22 and then the X chromosome. Note the characteristic differences in size and position of the centromere and banding patterns among the chromosomes. This double set represents the number of chromosomes you have in each of your body (somatic) cells.

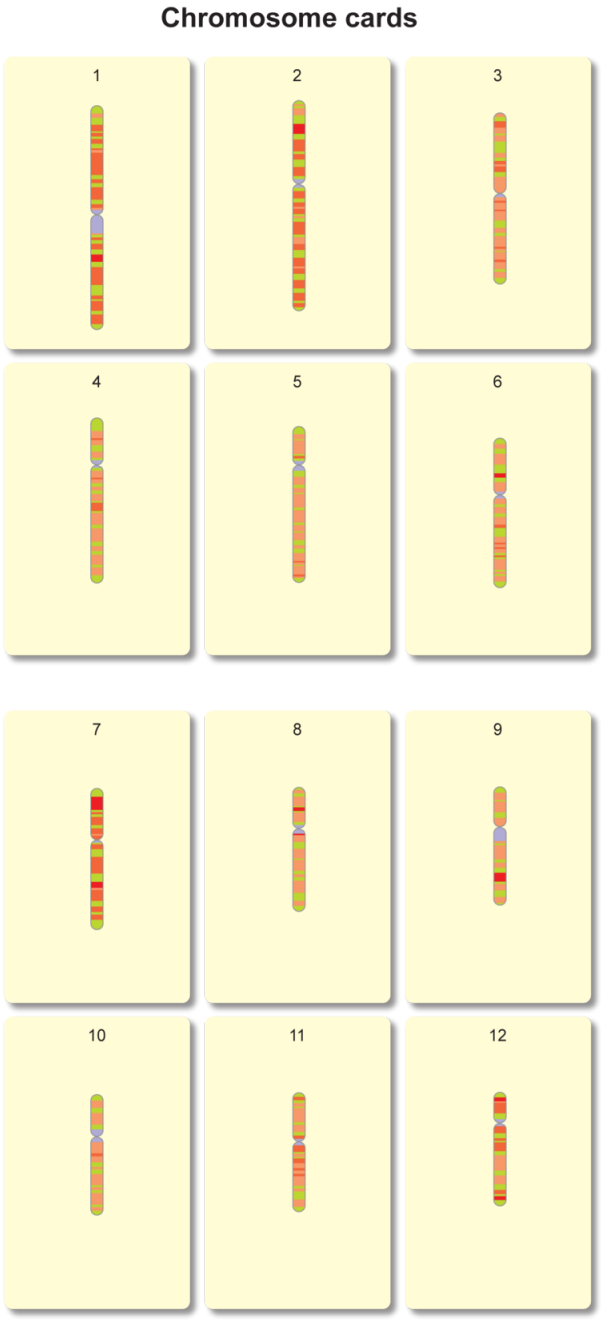
Step 3 Work with a partner who has a *different* colored set of cards.

Step 4 To represent DNA replication, take sticky tape and tape your partner's set of chromosomes to each of your chromosomes, pairing each homologous pair. For example, you will have green chromosome #1 linked to yellow chromosome #1. The tape represents the centromere. That is the amount of genetic material that you have in a somatic cell just after DNA replication, but before cell division. The difference is that each chromosome is joined at the centromere so that you have two sister chromatids linked together.

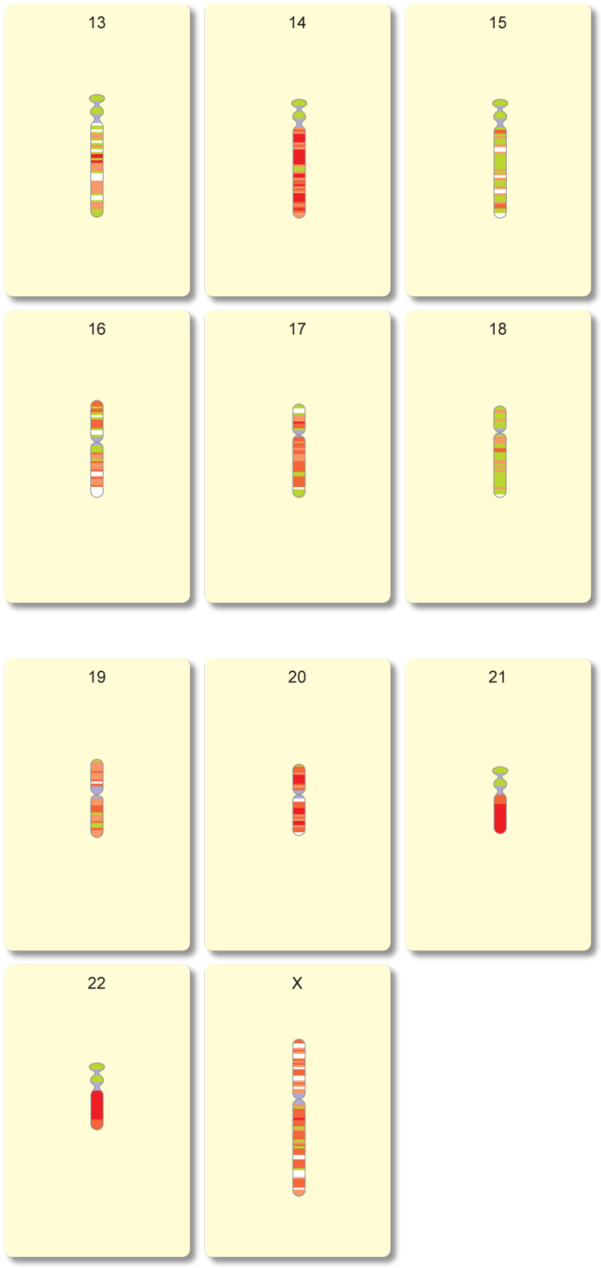
Step 5 Line up your chromosomes in the center of the large sheet of construction paper along the same plane (in single-file order). Separate each of the sister chromatids that are taped together. Send one of each pair to each end of the large piece of construction paper. You can see that each half of the construction paper has a complete set of chromosomes.

Step 6 Cut the butcher paper in the middle. Now you have two cells, each with a complete set of 46 single chromosomes. What do you conclude about the overall outcome of mitosis in terms of chromosome content? Is each daughter cell the same?

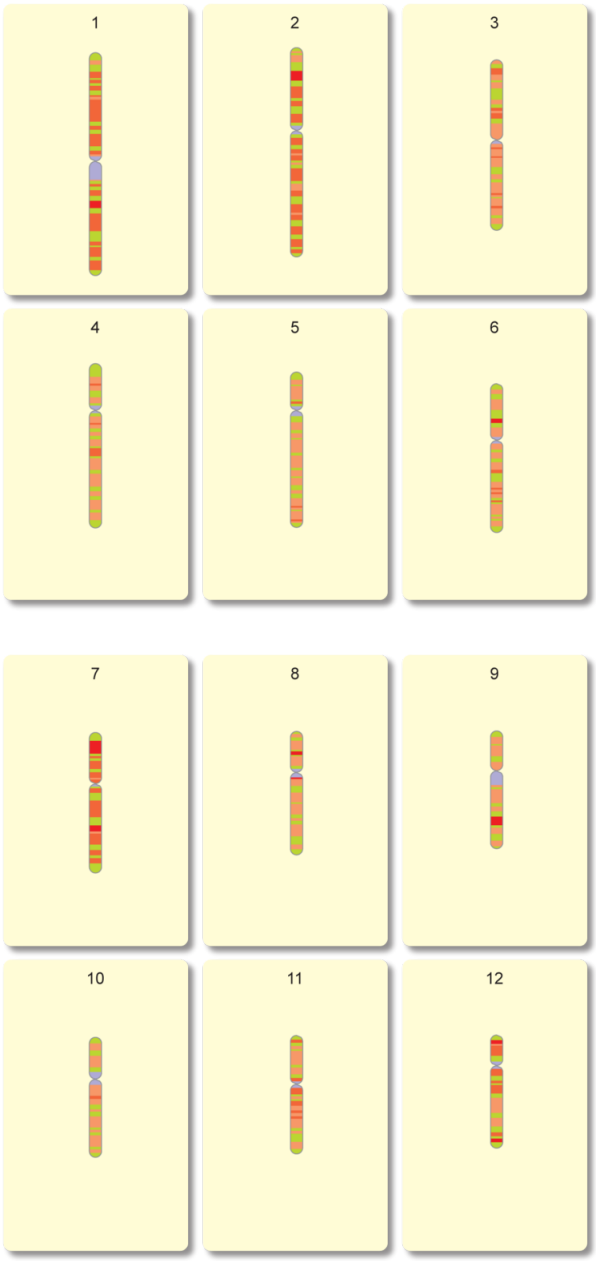
Activity 3-2 Resource 2: Cell Division-Double or Nothing (Student Reproducible)



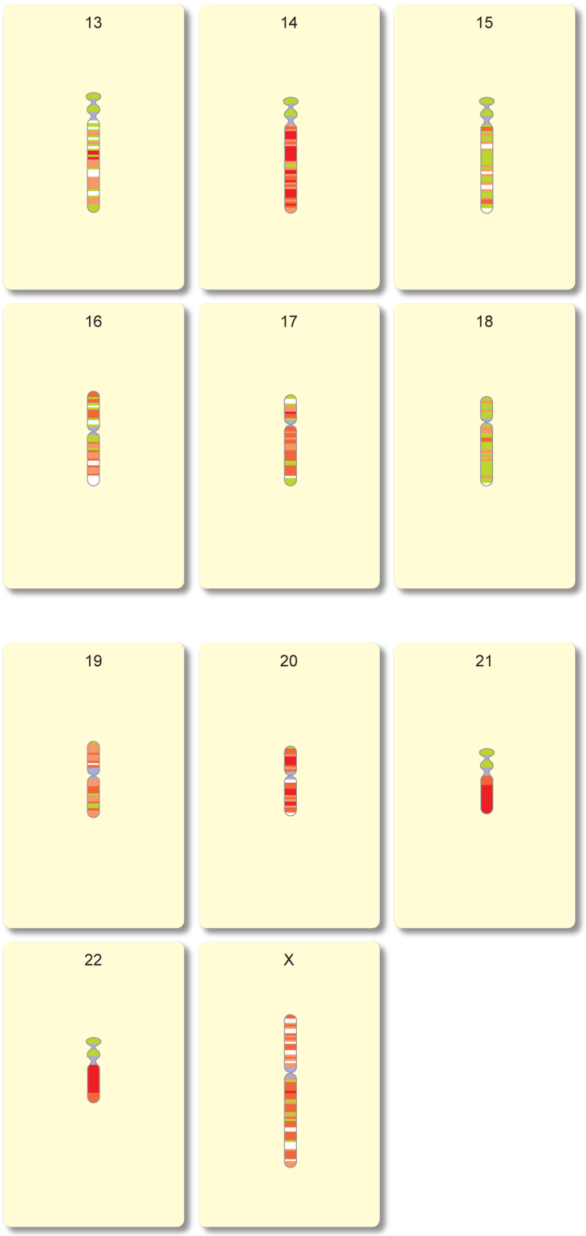
Chromosome cards



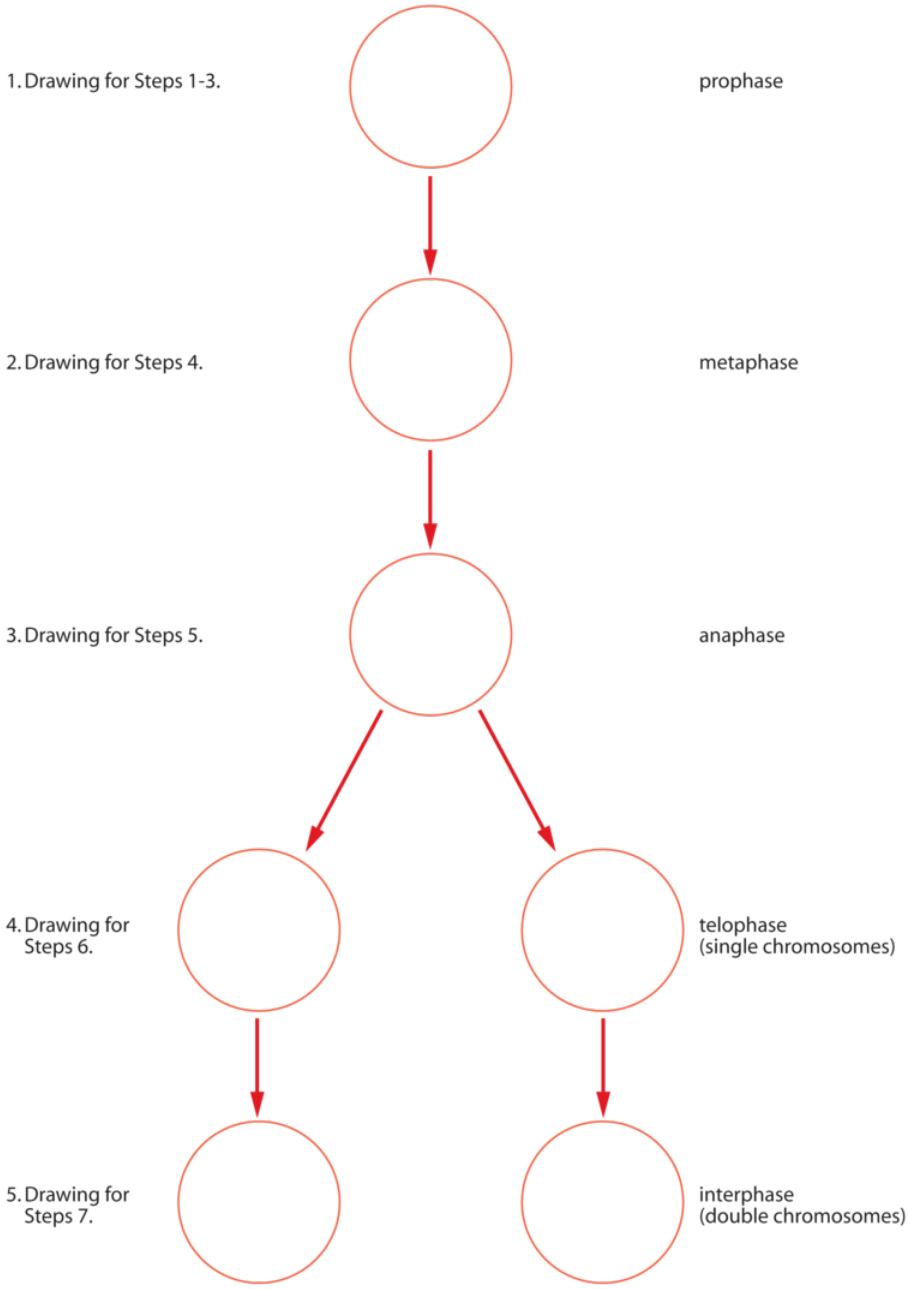
Chromosome cards



Chromosome cards



Activity 3-2 Report: Cell Division-Double or Nothing (Student Reproducible)



Activity 3-2 Report: Cell Division-Double or Nothing (Student Reproducible)

1. Compare the chromosome number of the parent cell with that of each of the two daughter cells.

2. Compare the genetic information of the parent cell with that of each of the two daughter cells with single chromosomes.

3. What is the importance of mitosis to the organism?

4. You have 46 chromosomes in each of your somatic cells. If you cut your arm, how many chromosomes would be in each newly formed skin cell?

5. Pretend that you are a double chromosome in the nucleus of a finger cell. Describe in a paragraph your experience going through cell division to become a new finger cell. Diagram as you did on your Activity Report.

4.4 Enrichment

Enrichment 3-1: Teacher Activity Notes

Exploring Osmosis

PLAN

Summary

Students explore osmosis using the selectively permeable membrane surrounding an uncooked egg and a dialysis membrane. Students compare the effects of osmosis in different concentrations of sugar solution and relate these experiments to osmosis that occurs inside cells.

Objectives

Students:

✓ explain the process of osmosis.

✓ compare the effects of different concentrations of sugar solution on osmosis.

✓ relate these experiments to osmosis that occurs inside cells.

Student Materials

- Activity Guide
- Resource (Optional)
- Activity Report
- Containers [5]
- Tap water [500 ml]
- Raw egg without shell (soaked in vinegar) [5]
- Sugar solution (concentrated such as corn syrup) [500 ml]
- Sugar solution (10%) [250 ml]
- Sugar solution (20%) [250 ml]

Teacher Materials

- Activity Report Answer Key
- Corn syrup
- Vinegar
- Resource, dialysis tubing (pieces IS-cm long), string, and scissors (Optional)

Advance Preparation

Review the Procedure in the Activity Guide on TE page 48 and decide if you want students to explore osmosis further using this activity.

Purchase chicken eggs. Prepare sugar solutions. Collect containers.

One or two days before doing activity, remove shells from eggs by placing them in a container. Pour enough vinegar into the container so that the eggs are completely submerged in the vinegar. Place container in a refrigerator overnight.

The acetic acid (HAc) in the vinegar will react with the calcium carbonate $(CaCO_3)$ of the shell to dissolve it, releasing bubbles of carbon dioxide (CO_2) . Once the shell has been removed, the egg membrane will be exposed and very easily punctured. Be careful when handling these eggs without their shells.

Review the Procedure on the student Activity Guide on TE page 48 and decide if you want students to explore osmosis further using this activity. If you choose to have students do the activity extension, cut dialysis tubing into 15-cm lengths, one per team. Soak dialysis tubing in water for 15-30 minutes before using to make it easier for students to work with the tubing. Make dialysis tubing and copies of the student Activity Guide available to students.

Estimated Time

2 class periods

Prerequisites and Background

Students should have some knowledge of the process of osmosis. Knowledge of the structure of the cell, particularly the cell membrane and its role in regulating passage of materials into and out of the cell, is important.

IMPLEMENT

- Provide students with a copy of the Activity Guide. You may want to review the Procedure with your students, including percent sugar calculations before they begin the activity. Make sure students do Day 1, Parts A, B, and C during the first class period. Then have them do Day 2, Parts A, B, and C during the next day's class period.
- Share with students how the eggshell was removed.
- Remind students to be careful with the solutions and the eggs.
- Upon completion of the activity, encourage students to design an experiment to demonstrate osmosis using dialysis tubing (a selectively permeable membrane). Use the Resource provided.

Helpful Hints

- Encourage students to investigate the effects of other osmotic environments. As an example, students could compare the effects of water (hypotonic), concentrated salt solution (hypertonic), and a water solution with just a trace of salt on eggs without shells.
- Students can investigate the effects of osmosis using a plant cell such as the aquarium plant *elodea*.
- Ask students to think of examples of osmosis that we see in our daily lives, such as in the grocery store where vegetables are often sprayed with water, kept moist, in order to help cells retain water and remain crisp.
- Explain to students that saline solution, with a 0.9% salt concentration, is often used to replenish blood volume in an IV. Ask them to explain why this is used instead of water. They determine that the blood normally must be slightly salty and, therefore, must receive an infusion of saline that has a similar salt concentration in order to maintain homeostasis and intact blood cells. An infusion of pure water would cause the red blood cells to burst due to too much water flowing into the cells.
- Ask students to compare osmosis in plant cells (having a cell wall) and in animal cells (having no cell walls).

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ explain the process of osmosis.

✓ compare the effects of different concentrations of sugar solution on osmosis.

✓ relate these experiments to osmosis that occurs inside cells.

Enrichment Activity 3-1: Exploring Osmosis – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Why are vegetables sprayed with fresh water in your local grocery store? What if you substituted salt water for fresh water? Explain.
2. Explain why it is a good idea to wait until the last minute to add salad dressing to a lettuce salad.
3. When salt is poured on a snail or slug, bubbles (foam) appear. How would you explain this?
4. Why is it important in making jam or jelly to add additional sugar? Could you substitute salt? Explain.
5. What is the relationship between salt intake and high blood pressure?

Enrichment 3-1 Activity Guide: Exploring Osmosis (Student Reproducible)

Introduction

What is osmosis? Why is it important? How is it different from diffusion? Osmosis, like diffusion, requires a difference in concentration and molecular motion of a substance. Osmosis is a special kind of diffusion. In addition to concentration and molecular motion, osmosis requires the substance to be water moving through a selectively permeable membrane.

Materials

- Activity Report
- Containers [5]
- Tap water [500 ml]
- Raw egg without shell (soaked in vinegar) [5]
- Sugar solution (concentrated such as corn syrup) [500 ml]
- Sugar solution (10%) [250 ml]
- Sugar solution (20%) [250 ml]

PART A

Procedure for Observing Containers 1 and 2

DAY 1

Step 1 Design a data table that includes space to illustrate the procedure, predictions, and recorded observations for 5 eggs.

Step 2 Label and fill container 1 half full of tap water. You need enough water to cover an egg.

Step 3 Obtain a raw egg that has been soaked in vinegar to remove the shell and carefully place the egg in container 1.

Step 4 Repeat Steps 2 and 3 using container 2. Add 10-20 drops of food coloring.

Step 5 Predict what you think will happen to each egg. Give a reason for your prediction. Record your prediction and reason on your data table.

Step 6 Observe the eggs carefully and make a labeled drawing of your observations on your data table for both eggs.

Step 7 Place containers 1 and 2 in a safe place until tomorrow.

DAY 2

Step 8 Observe the eggs carefully and make a labeled drawing of your observations for both eggs. Note any changes in the eggs in containers 1 and 2 from day 1. Brainstorm with your lab partners to explain what happened to cause any changes.

Add descriptions on your data table to illustrate any changes you see.

Step 9 *Save containers 1 and 2 containing tap water and eggs for use as controls for Parts B and C.*

PART B

Procedure for Observing Container 3 (egg in concentrated sugar solution)

DAY 1

Step 1 Label and fill container 3 half full of concentrated sugar solution such as Karo syrup (light). You need enough sugar solution to cover the egg.

Step 2 Obtain a raw egg that has been soaked in vinegar to remove the shell and carefully place the egg into container 3.

Step 3 Observe the egg carefully and make a labeled drawing of your observations on your data table.

Step 4 Predict what you think will happen to the egg. Give a reason for your predictions. Record your prediction and reason on your data table.

Step 5 Place container 3 in a safe place until tomorrow.

DAY 2

Step 6 Observe the egg carefully and make a labeled drawing of your observations on your data table. Note any changes in the egg in container 3 from day 1. Brainstorm with your lab partners to explain what happened to cause any changes.

Be sure to add descriptions on your data table to illustrate any changes you see.

PART C

Procedure for Observing Containers 4 and 5 (eggs in a dilute sugar solution)

DAY 1

Step 1 Let a concentrated sugar solution represent a 100% sugar solution. What do you think would happen if you set up eggs without shells in varying concentrations of the sugar solutions?

For example:

a. 5 ml of a concentrated sugar solution combined with 95 ml of water. What is the percent sugar concentration of this solution?

$$\frac{\text{part}}{\text{total}} \times 100 = \text{percent} \qquad \frac{5}{100} \times 100 = 5 \text{ percent}$$

b. 25 ml of concentrated sugar solution combined with 225 ml of water. What is the percent sugar concentration of this solution?

Step 2 Place 250 ml of a solution that has a sugar concentration of 10 percent into container 4 and label.

Step 3 Place 250 ml of a solution that has a sugar concentration of 20 percent into container 5 and label.

Step 4 Carefully place a raw egg without a shell into containers 4 and 5.

Step 5 Predict what you think will happen to the eggs in containers 4 and 5. Be sure to give a reason for your predictions. Record your predictions and your reasons on your data table.

Step 6 Place containers 4 and 5 in a safe place until tomorrow.

DAY 2

Step 7 Observe the eggs carefully and make a labeled drawing of your observations for both eggs. Note any changes in the eggs in containers 4 and 5 from day 1. Brainstorm with your lab partners to explain what happened to cause any changes.

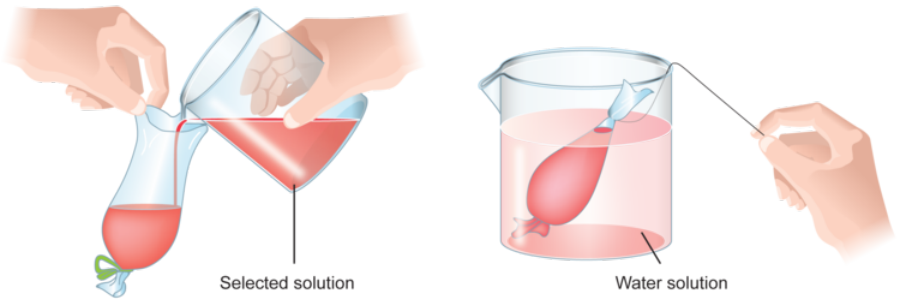
Add descriptions on your data table to illustrate any changes you see.

Enrichment 3-1 Resource: Exploring Osmosis (Student Reproducible)

Procedure

Step 1 Working with your partner or group, design an experiment to demonstrate osmosis through a selectively permeable membrane. Your experimental design should (a) use a control, (b) test only one variable at a time, and (c) allow for the collection of data.

Step 2 Have your group agree on a hypothesis to be tested. Determine what materials you will need. A piece of dialysis tubing 15 cm long will represent the selective membrane. You may want to use selected sugar solutions from Part C.



Step 3 Check with your teacher for final approval of your experimental plan, required supplies, and hypothesis.

Step 4 Discuss and answer with your group the following questions.

a. What will be your control?

b. What variable are you going to test?

c. What data are you going to collect?

d. How did you design and make your data table?

e. What will be the responsibility of each group member?

Step 5 Carry out your experiment, recording your observations in your data table.

Step 6 Follow the directions of your teacher to clean up.

Enrichment 3-1 Activity Report: Exploring Osmosis (Student Reproducible)

1. Why are vegetables sprayed with fresh water in your local grocery store? What if you substituted salt water for fresh water? Explain.

2. Explain why it is a good idea to wait until the last minute to add salad dressing to a lettuce salad.

3. When salt is poured on a snail or slug, bubbles (foam) appear. How would you explain this?

4. Why is it important in making jam or jelly to add additional sugar? Could you substitute salt? Explain.

5. What is the relationship between salt intake and high blood pressure?

CHAPTER 5 DNA and the Genetic code - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

5.1 Planning

Key Ideas

- The genetic information contained in cells is stored in DNA molecules and copied accurately so that each daughter cell receives the same information.
- The genetic code is represented by sequences of triplet nucleotides in the DNA molecules.
- Different cell types in your body use or express different portions of your DNA called genes. Genes code for the production of specific proteins in the cell.
- The transcription of mRNA and its translation at the ribosomes are the processes involved in making proteins.

Overview

Students learn about DNA and the information it stores in the genetic code. They explore the physical structure of DNA. Then they learn how it is replicated by building and manipulating a model of a DNA double helix. Students also isolate DNA from thymus tissue to observe its texture and study other physical properties of the molecule. They investigate the process by which the mRNA code is transcribed from the DNA code for a gene, and then how mRNA is translated into protein at the ribosomes.

Objectives

Students:

✓ describe the composition and structure of DNA.

✓ demonstrate how DNA replicates.

✓ explain the roles of DNA, mRNA, tRNA, and amino acids in making protein.

✓ describe how the genetic code is expressed in different cells.

Vocabulary

amino acids, codon, DNA polymerases, double helix, genes, helicase, messenger ribonucleic acid (mRNA), nucleotides, replication, RNA polymerase, transcription, transfer RNA (tRNA)

Student Materials

Activity 4-1: Removing DNA from Thymus Cells

- Activity Report
- Safety goggles
- Sample of fresh thymus cells in a beaker; Sand; Liquid soap, clear, in a beaker with an eyedropper; Water in a beaker with an eyedropper; Alcohol; Cheesecloth square (several layers, 15×15 *cm*); Mortar and pestle; Test tube; Small funnel; Test tube rack; Wooden skewer; Forceps; Eyedropper; Permanent marking pen; Paper towels; Black construction paper, 4×4 *cm* ; Transparent tape; Microscope, slides, and cover slips

Activity 4-2: Building and Using a DNA Model

- Resource
- Activity Report
- Scissors; Paper; 6 different sets of colored paper; Tape

Teacher Materials

Activity 4-1: Removing DNA from Thymus Cells

- Activity Report Answer Key
- Serrated knife for cutting the thymus tissue
- Extra student materials, especially cheesecloth, skewers, test tubes, and fresh thymus cells

You can substitute glass for the stirring rod.

Methylene blue stain can be used to stain the thymus nuclei in Step 5.

Optional: DNA visuals, including models and/or posters

Model of a cell with a large, distinct nucleus

Picture of a human torso to show the location of the thymus gland

Activity 4-2: Building and Using a DNA Model

- Activity Report Answer Key
- Models and diagrams of DNA molecules and nucleotides

Advance Preparation

See Activities 4-1 and 4-2 in the Student Edition.

Activity 4-1: Removing DNA from Thymus Cells

- Purchase fresh thymus tissue, also called sweetbreads, from your local butcher. You can freeze the thymus tissue if you do not plan to use it right away.
- Cut the thymus tissue into 2 cm cubes using a clean knife.
- Keep all solutions cold prior to activity.

Activity 4-2: Building and Using a DNA Model

- You can have students color the sugars, phosphates, and nitrogen bases as follows. Or you can copy them on the indicated colors of paper.
- 60 deoxyribose sugars (white)
- 60 phosphates (orange)
- 15 of *each* of the four nitrogenous bases:
  - adenine (red), thymine (blue), cytosine (yellow), and guanine (green)
- Allow ample time to pre-cut the template pieces.

Interdisciplinary Connections

Math Relate the repeating patterns of triplet nucleotides in DNA to other mathematical patterns.

Social Studies Investigate and write about the history and uses of the Morse code.

Language Arts Write a narrative describing the "synthesis of a protein."

Enrichment Activity

Enrichment 4-1: Making Protein

5.2 Using DNA and the Genetic Code – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Emphasize that DNA molecules have the genetic information and make copies or replicate themselves so that the daughter cells get the same information.

Begin this section with *Activity 4-1: Removing DNA from Thymus Cells.*

Discuss the composition of nucleotides and how they are organized in the DNA molecule.

Discuss the role of models in science.

Assign *Activity 4-2: Building and Using a DNA Model.*

Stress the important roles of DNA, mRNA, tRNA, and amino acids in making proteins. Discuss the processes of transcription and translation.

Assign *Mini Activity: Coding.* The secret message is *"HumBio is humming"* followed by *Apply Your Knowledge.* Emphasize how the genetic code is represented by the sequence of triplet nucleotides of DNA molecules.

Select appropriate Projects and other activities if time permits.

Emphasize the big ideas of this section by discussing answers to the Review Questions.

At the end of the section refocus students' attention on the key ideas.

5.3 Activities and Answer Keys

Activity 4-1: Removing DNA from Thymus Cells

PLAN

Summary Students treat fresh thymus tissue, (sweetbreads) to remove its DNA. They precipitate, spool, and observe the DNA in a test tube. Students design an alternative procedure to isolate thymus DNA. They also consider different tissue sources for obtaining DNA.

Objectives

Students:

✓ extract the DNA from the nuclei of thymus cells.

✓ describe the physical properties of DNA.

✓ design an alternative procedure to isolate thymus DNA.

Student Materials

- Safety goggles
- Activity Report
- Sample of fresh thymus cells in a beaker; Sand; Liquid soap, clear, in a beaker with an eyedropper; Water in a beaker with an eyedropper; Alcohol; Cheesecloth square (several layers, 15×15 *cm*); Mortar and pestle; Test tube; Small funnel; Test tube rack; Wooden skewer; Forceps; Eyedropper; Permanent marking pen; Paper towels; Black construction paper, 4×4 *cm* ; Transparent tape; Microscope, slides, and cover slips

Teacher Materials

- Activity Report Answer Key
- Serrated knife for cutting the thymus tissue
- Extra student materials, especially cheesecloth, skewers, test tubes, and fresh thymus cells
- You can substitute plastic or glass for the stirring rod.
- Methylene blue stain can be used to stain the thymus nuclei in Step 5.

Optional: DNA visuals, including models and/or posters Model of a cell with a large, distinct nucleus

Picture of a human torso to show the location of the thymus gland

Advance Preparation

Purchase fresh thymus tissue, also called sweetbreads, from your local butcher. You can freeze the thymus tissue if you do not plan to use right away.

Cut the thymus tissue into 2 cm cubes using a clean knife.

Keep all solutions cold prior to beginning the activity.

Estimated Time One to two class periods

Interdisciplinary Connection

Art Make a 3-D model of DNA.

Prerequisites and Background

Students should have good microscope skills. If the microscopes use mirrors and natural light, remind students not to point the mirror directly at the Sun. This activity is a great way to introduce and motivate the student to learn more about deoxyribonucleic acid (DNA).

DNA is not very soluble in 95-100% ethyl alcohol. It is at the interface where the DNA layer comes in contact with the alcohol layer that the DNA precipitates out of solution and can be spooled onto a *clean*, wooden skewer, glass rod, or pipette. Do not use plastic.

IMPLEMENT

Introduce Activity 4-1 by reminding students of safety procedures in the lab, such as safety when using microscopes and wearing goggles when working with alcohol.

Point out the location of the thymus gland on a picture of a human torso.

Set up a slide to show intact thymus cells.

Steps 1-14 Be sure students are using their Activity Report as they progress through the Procedure.

Step 4 Monitor disposal of thymus tissue and clean up.

Step 5 This step can be done as a demonstration.

Steps 6-7 Make sure students only tap gently.

Step 8 Demonstrate how to trickle the alcohol down the inside of the test tube.

Steps 9-12 Monitor the disposal of materials and the general cleanup process. Again, make sure students are recording responses on their Activity Reports.

Step 13 Include a discussion of controls and variables to help students.

Step 14 Remind students to wash their hands thoroughly at the end of the activity.

Helpful Hints

- Use a clear detergent.
- Any alcohol such as ethanol, isopropanol, or rubbing alcohol can be used.
- Have students evaluate how they liked designing their own experiments and if it helped them learn more about DNA.

ASSESS

Use the completion of the activity and written responses to the Activity Report to assess if students can

✓ identify the location of DNA in thymus cells.

✓ describe the physical properties of DNA.

✓ design an alternative procedure to isolate thymus DNA.

✓ identify different tissue sources for obtaining DNA.

Activity 4-1: Removing DNA from Thymus Cells – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the purpose of the thymus tissue?
2. Make a drawing of your observations. You should be able to see the nuclei from the thymus cells. Be sure to label a few nuclei.
3. Which part of the cell was broken by the sand and grinding? Which part was broken by the soap?
4. Draw a labeled diagram and explain in words what happened when the alcohol was added to the test tube.
5. What is the purpose of twirling the wooden skewer?
6. Describe the appearance and texture of the DNA.
7. Describe your alternative procedure for removing thymus DNA. Include labeled diagrams as needed.
8. Explain how you would modify your original experimental design using different sources of DNA.

What Do You Think?
What other processes use templates to produce a copy of something?

Activity 4-2: Building and Using a DNA Model

PLAN

Summary Students make paper models of DNA nucleotides and use them to construct a DNA molecule consisting of twelve nucleotide pairs. They then use this DNA model to simulate the process of DNA replication.

Objectives

Students:

✓ build models of DNA nucleotides.

✓ construct a model of a DNA double helix.

✓ simulate the replication of DNA.

Student Materials

- Resource
- Activity Report
- Scissors
- 6 different sets of colored paper
- Tape

Teacher Materials

- Activity Report Answer Key
- Models and diagrams of DNA molecules and nucleotides
- Extra supply of colored paper (6 colors noted below)

Advance Preparation

You can have students color the sugars, phosphates, and nitrogen bases as follows. Or you can copy them on the indicated colors of paper.

60 deoxyribose sugars (white)

60 phosphates (orange)

15 of *each* of the four nitrogenous bases:

adenine (red), thymine (blue), cytosine (yellow), and guanine (green)

Allow ample time to precut the template pieces.

Estimated Time One to two class periods, if template pieces have been precut

Interdisciplinary Connection

Math Relate the repeating patterns of nucleotides in DNA to other patterns in math.

Prerequisites and Background

Students should read and/or discuss the text material on DNA and replication before beginning this activity.

IMPLEMENT

Students can work in lab teams of two to four. As indicated in the Advance Preparation, you can have students color the sugars, phosphates, and nitrogen bases as follows.

60 deoxyribose sugars (white)

60 phosphates (orange)

15 of *each* of the four nitrogenous bases:

adenine (red), thymine (blue), cytosine (yellow), and guanine (green).

It takes about one class period to color and cut out the templates. This can be done at home. It is important that the same color code is used for the different parts of the DNA nucleotides. Or you can copy them on paper of the colors indicated above.

Introduce Activity 4-2 by demonstrating how to put together a nucleotide and then how to combine the nucleotides into a DNA molecule.

> **Helpful Hints**
> Instead of using the colored paper for the copies of the templates, students can color both sides of the templates with pens or crayons.

Step 1-3 Remind students that they can sequence the nucleotides in any way they choose, but they should use no more than seven of each nucleotide.

Remind students to save extra nucleotides for simulating replication.

Step 4 Remind students to complete items 1 to 5 on their Activity Reports.

Step 5 Confirm students can explain replication.

Steps 6 Remind students to complete their Activity Reports and show them where they should store their completed models.

ASSESS

Use the construction of the nucleotides and DNA double helix, the simulation of DNA replication, and the written answers on the Activity Report to assess if students can

✓ build accurate models of nucleotides.

✓ construct an accurate model of a DNA double helix.

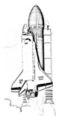
✓ explain the structure of DNA.

✓ simulate the replication of DNA.

Activity 4-2: Building and Using a DNA Model – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What are the three components of a nucleotide molecule?
2. What makes up the "rungs" of the DNA ladder?
3. What makes up the sides (uprights) of the DNA ladder?
4. What are the possible combinations of nitrogen bases?
5. Make a drawing of your completed DNA model. Be sure to include labels.
6. Make a drawing of the process of replication (Steps 5 and 6).
7. How do the replicated DNA molecules compare with the original DNA molecule?



Mini-Activity

Coding Students learn about the genetic code by using a variation of the mRNA code to solve a secret message. The secret message says, "HumBio is humming."

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Write a sentence in which each word is made up of three letters, but do not leave spaces between the words, and do not use a period at the end of the sentence. Use the Code Key in the *Mini Activity: Coding*. What rules do you have to use to read this sentence? Explain why RNA polymerase must have start and stop signals. What start and stop signals would make it possible for someone to read your message correctly?

Mini-Activity

Building a Protein Model Pop beads can be obtained from any crafts store. Students may have pop beads at home. Students use 20 different colored pop beads or other colored plastic beads to simulate a protein chain of fifty amino acids and then compare their chains to see if they are similar, very different, or exactly alike. They relate their comparisons of the different pop bead proteins to the number of proteins that can be made from 20 different amino acids.

Journal Writing

There are hundreds of different languages spoken around the world. Why do you think there are so many languages? How would you investigate which languages are related to each other? Can you speak

more than one language, or would you like to be able to? What are some advantages of being able to speak more than one language?

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Consider your answer to the Journal Writing on this page with respect to how you would investigate whether different languages are related. How could you investigate whether different animals are related based on their genetic codes and proteins? How could you tell which animals were more and which were less closely related?

Apply Your KNOWLEDGE

What does "poly" mean in the word *polypeptide?* What are some other words that use "poly" in this way?

Apply Your KNOWLEDGE

1. **Write a code using the letters A, U, G, and C for the nucleotides in mRNA.**
2. **Now design the triplets for the transfer RNAs that are complementary to this message.**
3. **What would happen if, in the first triplet, the A was missing and the message began with a U?**
4. **What else could you do that would change (mutate) the original message for making a functional protein into a meaningless message?**

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Describe how DNA makes a copy of itself.
2. Explain the role of DNA, mRNA, and amino acids in making a protein. DNA contains the code for making a particular protein.
3. What is the genetic code? How does it work?
4. How are amino acids brought into the sequence that is specified by the mRNA code?

Activity 4-1 Report: Removing DNA from Thymus Cells (Student Reproducible)

1. What is the purpose of the thymus tissue?

2. Make a drawing of your observations. You should be able to see the nuclei from the thymus cells. Be sure to label a few nuclei.

3. Which part of the cell was broken by the sand and grinding? Which part was broken by the soap?

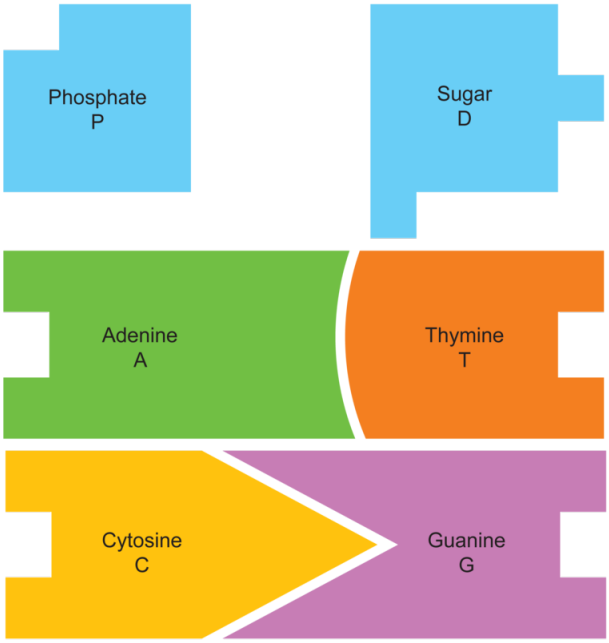
4. Draw a labeled diagram and explain in words what happened when the alcohol was added to the test tube.

5. What is the purpose of twirling the wooden skewer?
6. Describe the appearance and texture of the DNA.

In the space below, attach the paper containing your specimen. Label the DNA.

7. Describe your alternative procedure for removing thymus DNA. Include labeled diagrams as needed.
8. Explain how you would modify your original experimental design using different sources of DNA.

Activity 4-2 Resource: Building and Using a DNA Model (Student Reproducible)



Activity 4-2 Report: Building and Using a DNA Model (Student Reproducible)

1. What are the three components of a nucleotide molecule?
2. What makes up the “rungs” of the DNA ladder?
3. What makes up the sides (uprights) of the DNA ladder?
4. What are the possible combinations of nitrogen bases?
5. Make a drawing of your completed DNA model. Be sure to include labels.
6. Make a drawing of the process of replication (Steps 5 and 6).
7. How do the replicated DNA molecules compare with the original DNA molecule?

5.4 Enrichment

Enrichment 4-1: Teacher Activity Notes

Making Protein

PLAN

Summary

Students perform in a play that simulates where and how proteins are made within the cell. They demonstrate the functions of DNA and RNA in the synthesis of protein. Students identify the important functions of proteins in the body, using hemoglobin as an example.

Objectives

Students:

✓ simulate the process of protein synthesis.

✓ identify the roles of DNA, RNA, and amino acids in the synthesis of protein.

✓ explain why proteins are important in the body.

Student Materials

- Signs

DNA (GGT-CTC-CTC)

Make Protein

Messenger RNA (mRNA)

Transfer RNA (tRNA)/Proline

Transfer RNA (tRNA)/Glutamic Acid 1

Transfer RNA (tRNA)/Glutamic Acid 2

Amino Acid Proline (reverse side: The)

Amino Acid Glutamic Acid 1 (reverse side: Protein)

Amino Acid Glutamic Acid 2 (reverse side: Hemoglobin)

Ribosome (3)

- Activity Guide
- String or rope
- Activity Report

Teacher Materials

- Resource (Optional)

- Activity Report Answer Key

Advance Preparation

1. Make signs for each of the roles. If the signs are to be computer-generated, print the roles on 8.5×11 -inch sheets of paper. Staple or glue the sheets onto a piece of construction paper. Color code for roles requiring more than one player, such as tRNA and its corresponding amino acid. An alternative is to print the role names on colored construction paper.
2. Punch two holes in each sign and attach a piece of string so that the sign can be worn around the player's neck.
3. Prepare a copy of the selected script for each player (9 copies). Highlight each player's part throughout the script. It might be helpful to provide scripts for all members of the class. As an option use the Resource provided as the script.
4. Arrange the string/rope in a large circle to represent the cell membrane. You could also use chalk to represent the cell membrane.
5. Mark off a circle inside the cell to represent the nucleus.
6. Place ribosome signs inside the cell membrane.

Estimated Time 50-minute class period

Interdisciplinary Connections

Physical Education or Visual/Performing Arts may have a classroom large enough to accommodate this activity.

Art Create a set of models to simulate protein production within the cell. Use these models to explain the process of protein synthesis to the class.

Language Arts Write a narrative describing the "synthesis of protein."

Prerequisites and Background

Students should have some knowledge of cell structures involved in protein synthesis. Students should know that proteins are composed of amino acids. Knowledge of the process of protein synthesis is helpful.

Background Information

Review transcription (the process of DNA making mRNA) and translation (the process of mRNA being "read" at the ribosome to form proteins). In this play, Act I simulates transcription (DNA making mRNA). Act 2 simulates translation (mRNA making protein).

mRNA processing (removal of introns and splicing of exons) is omitted from this play as it is a topic better addressed in high school.

The hemoglobin molecule is a large protein composed of 574 amino acids. This activity refers to a sequence of only three of these amino acids to illustrate how proteins are made.

In the DNA sequence for hemoglobin, if one of the DNA triplets "CTC" mutates to "CAC" then a corresponding change in the mRNA results ("GAG" becomes "GUG"). Instead of glutamic acid, the amino acid valine is introduced. This change of one amino acid is sufficient to alter the shape and consequently the function of the hemoglobin (protein) molecule so drastically that it becomes severely limited in its ability to carry oxygen efficiently. People with this mutation can have sickle cell anemia, a very serious blood disorder.

IMPLEMENT

Step 1 You may want students to write their own scripts. Or you can use the prepared scripts on the Resource.

Step 2 As a class, decide what scripts will be used. Make copies of the selected scripts

Step 3 Arrange a place on the floor for students to make a human marrow cell that produces hemoglobin by placing a string or rope in a large circle to represent the cell membrane. This will become part of their set as they perform

their plays.

Step 4 Cast students or choose a few students to do the casting. Allow students time to become familiar with their respective roles after receiving the script. Have them practice their roles.

Step 5 After students have completed the procedure described, consider having the students practice and present Acts I and II using several messenger RNAs, transfer RNAs, and amino acids. These presentations should help students learn that protein synthesis occurs simultaneously at many sites within a cell.

Repeat the play, rotating the roles to help students learn how proteins are made.

Make adjustments to the script to double the number of players. Also consider adding codes for other amino acids in hemoglobin.

Helpful Hints

This activity can be done inside or outside the classroom.

- To involve more students, consider having students sit along the cell membrane to view the play or using students instead of string to represent the cell membrane.
- Consider videotaping the play.
- Encourage students to write another play to show how another protein, such as insulin, is formed.
- To illustrate mutations, students can change the sign of the DNA code CTC to CAC. The effect of such a mutation is described in the Background Information.
- Invite students to do research on types of hemoglobin and disorders of hemoglobin resulting in different kinds of anemia such as sickle cell, pernicious, and thalassemia.

ASSESS

Use the script, performances of the play, research on protein disorders, and written answers on the Activity Report to assess if students can

✓ demonstrate and explain how proteins are synthesized in the cell.

✓ identify the roles of DNA, mRNA, tRNA, and amino acids in the synthesis of protein.

✓ explain why proteins are important in the body.

✓ describe the effects of mutations on protein function.

Enrichment Activity 4-1: Making Protein – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Why are proteins important to the cells in your body? Give examples.
2. What is it that makes one protein different from another?
3. Use words and/or drawings to show that you know how proteins are made in your cells. Include in your answer the following: DNA, mRNA, tRNAs, ribosomes, amino acids, and protein.
4. What do you think would happen if your body incorrectly made a protein, such as hemoglobin?

Enrichment 4-1 Activity Guide: Making Protein (Student Reproducible)

Introduction

Where and how are proteins made in your body? What is the role of DNA? What is the role of RNA? Ribosomes? In this activity you write a script or use one provided by your teacher and role-play important cell processes to show the role of DNA in making mRNA and the role of mRNA in making protein.

Materials

- Signs, string, rope
- Activity Report

TABLE 5.1:

Players	Signs
a. Narrator	Narrator
b. DNA	DNA (GGT-CTC-CTC) Make Protein
c. Messenger RNA (mRNA)	Messenger RNA (mRNA)
d. Transfer RNA (tRNA) for Proline	Transfer RNA (tRNA)/Proline
e. Transfer RNA (tRNA) for Glutamic Acid 1	Transfer RNA (tRNA)/Glutamic Acid 1
f. Transfer RNA (tRNA) for Glutamic Acid 2	Transfer RNA (tRNA)/Glutamic Acid 2
g. Amino Acid Proline	Amino Acid Proline (reverse side: The)
h. Amino Acid Glutamic Acid 1	Amino Acid Glutamic Acid 1 (reverse side: Protein)
i. Amino Acid Glutamic Acid 2	Amino Acid Glutamic Acid 2 (reverse side: Hemoglobin)
	Ribosome (3) placed inside the cell

Procedure

Step 1 Write a script (or use the script provided in the Resource) describing the steps involved in making a protein.

Step 2 If you write an original script, share your script with the class. Determine which of the scripts will be used for class presentation. Your teacher will provide copies for the players.

Step 3 Make a human bone marrow cell that produces hemoglobin by placing

- a long piece of string or rope in a circle on the floor to represent the cell membrane.
- a shorter piece of string or rope on the floor inside the cell membrane to represent the nucleus.
- several signs labeled “ribosome” on the floor outside the nucleus.

Step 4 Identify players and have them make and display their signs.

Step 5 Players take their positions, rehearse, and then perform the acts of the play.

Enrichment 4-1 Resource-Script: Making Protein (Student Reproducible)

Instructions to the players are in *italics.* These lines should not be read aloud.

Act I: A Day in the Life of DNA

Narrator: Proteins are important to the cell. Remember that proteins are made out of building blocks called amino acids. Most of the necessary amino acids are in the food you eat. How are these amino acids put together into the specific proteins your body needs? How do cells in your body make proteins, such as hemoglobin?

The answer is through the activities of DNA and RNA in your cells. Let us look at what must happen when DNA tells your cells to make (synthesize) a new protein using amino acids.

Imagine that we can see inside the nucleus and hear what DNA is saying . . .

Scene 1: DNA in the Nucleus

DNA: I am DNA! I carry the code for making proteins, including hemoglobin that carries oxygen in your red blood cells. Let us follow the events in the making of the protein hemoglobin inside cells in your bone marrow. Since I am such a big important molecule, I cannot leave the nucleus. Therefore, I will send my code for making hemoglobin with my friend, mRNA. First, I make mRNA so it can carry information for hemoglobin. Then I watch while mRNA leaves the nucleus to go out into the cell cytoplasm.

*(Holds up a **Make Protein** sign and reads the message)*

Make Protein.

(DNA turns around and takes hold of one hand of messenger RNA and rotates around.

*DNA lets go of mRNA's hand. mRNA takes the **Make Protein** sign from DNA, turns around, and walks out of the nucleus toward one of the ribosomes of the cell.)*

Act II: A Day in the Life of Amino Acids

Narrator: Scene 1: mRNA at the Ribosomes

mRNA: I am mRNA! I have the coded message from DNA that specifies the order of amino acids necessary to make the protein hemoglobin. Now, I have reached the ribosome, where proteins are actually made. Let's get started making a hemoglobin molecule!

I will demonstrate making part of the protein hemoglobin using only 3 amino acids instead of its 574 required amino acids.

First I need the amino acid Proline. Proline's tRNA, where are you?

(tRNA/Proline finds the amino acid Proline. Transfer RNA uses left hand to grab proline's right hand. tRNA/Proline holding hands with Proline, goes to the ribosome where messenger RNA is located.)

Proline: Here we are!

mRNA: Come here! I need you now!

(mRNA, with his or her left hand, grabs the right hand of Proline's tRNA.

mRNA swings left hand forward in order to use right hand to grab Proline's left hand. mRNA releases tRNA to leave the ribosome)

Narrator: Scene 2: mRNA at the Ribosome, looking for Glutamic Acid 1

mRNA: Now I need the amino acid Glutamic Acid. Glutamic Acid 1 and tRNA, where are you?

(mRNA looks around for Glutamic Acid 1 and its tRNA.

tRNA/Glutamic Acid 1 finds Glutamic Acid 1. Transfer RNA uses left hand to grab Glutamic Acid 1's right hand. tRNA/Glutamic Acid 1 holding hands with Glutamic Acid 1 goes to the ribosome where messenger RNA is located.)

Glutamic Acid 1: Here we are!

mRNA: Come here! I need you now!

(mRNA with his/her left hand grabs the right hand of left Glutamic Acid 1's tRNA.)

Now it is time for the two amino acids to join! Watch the amino acid chain begin!

(mRNA swings left hand forward in order to use right hand to grab Glutamic Acid's left hand.

Glutamic Acid 1 tells Proline to let go of mRNA. Glutamic Acid 1 grabs left hand Proline with the right hand, and mRNA with the left hand.

Glutamic Acid 1 tRNA is free to leave the ribosome)

Notice that two significant events just happened;

1. Proline has been brought to mRNA by its tRNA
2. Glutamic Acid has been brought to mRNA by its tRNA and joined to Proline.

Now the amino acid chain is ready to grow!

Narrator: Scene 3: mRNA at the Ribosome, looking for Glutamic Acid 2

mRNA: I am mRNA! I have the coded message from DNA that tells the order of amino acids necessary to make the protein hemoglobin. I have started making hemoglobin, the special protein that helps your blood carry oxygen to cells throughout the body.

It takes hundreds of amino acids to make the one protein. My job is not over. We have more work to do. Now I need another Glutamic Amino Acid. Glutamic Acid 2 and tRNA, where are you?

(mRNA looks around for Glutamic Acid 2 and its tRNA.

tRNA/Glutamic Acid 2 finds Glutamic Acid 2 Transfer RNA and uses left hand to grab Glutamic Acid 2's right hand. tRNA/Glutamic Acid 2 holding hands with Glutamic Acid 2 goes to the ribosome where messenger RNA is located.)

Glutamic Acid 2: Here we are!

mRNA: Come here! I need you now!

(mRNA with his/her left hand grabs the right hand of Glutamic Acid 2's tRNA.)

Now it is time for the third amino acid to join the amino acid chain. Watch the amino acid chain grow!

(mRNA swings left hand forward in order to use right hand to grab Glutamic Acid 2's left hand.

Glutamic Acid 2 tells Glutamic Acid 1 to let go of mRNA. Glutamic Acid 2 grabs left hand of Glutamic Acid 1 with the right hand and mRNA with the left hand.

Glutamic Acid 2 tRNA is free to leave the ribosome.)

Notice that three significant events have now happened:

1. Proline has been brought to mRNA by its tRNA.
2. Glutamic Acid 1 has been brought to mRNA by its tRNA and joined to Proline.
3. Glutamic Acid 2 has been brought to mRNA by its tRNA and joined to Glutamic Acid 1.

All tRNAs are now available again to find their specific amino acid.

This is how a protein is made! If this protein really was hemoglobin, the protein chain would be made up of 574 amino acids linked together.

Narrator: Scene 4: Completion of the Amino Acid Chain

This process will be continued many times in order to place the 574 amino acids in the correct sequence to make the hemoglobin protein.

Now, let's imagine that our protein is finished.

Notice that each tRNA has returned to the cytoplasm to find its complementary amino acid for making another protein.

Also, see how the mRNA is now able to code for another hemoglobin protein.

(mRNA moves to another ribosome to begin the process again)

Narrator: Scene 5: Finale

These are only three amino acids of the 574 amino acids required to make the protein hemoglobin!

Proline, Glutamic Acid 1, and We are now protein! We are now protein!

Glutamic Acid 2 (The Amino acid Group) *(The amino acid group turn over their signs and read their message.)*

The Protein Hemoglobin

(After reading their message, they leave the ribosome and the cell.)

Narrator: You have just witnessed how DNA makes mRNA and sends mRNA with its code for making protein to the ribosomes. Hemoglobin is only one of thousands of different proteins made by the different cell types in your body.

Enrichment 4-1 Activity Report: Making Protein (Student Reproducible)

1. Why are proteins important to the cells in your body? Give examples.

2. What is it that makes one protein different from another?

3. Use words and/or drawings to show that you know how proteins are made in your cells. Include in your answer the following: DNA, mRNA, tRNAs, ribosomes, amino acids, and protein.

4. What do you think would happen if cells in your body incorrectly made a protein, such as hemoglobin?

CHAPTER 6 The Health of Cells - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

6.1 Planning

Key Ideas

- Cells have important functions in maintaining homeostasis, or internal balance, within the body. Factors that affect the functions of cells come from within the body and from the external environment.
- A permanent change in the DNA of a cell is called a mutation.
- Cancer cells are different from normal cells in how they recognize other cell types, reproduce, move, and respond to chemical signals.
- Individuals can lower their risk of developing certain kinds of cancer by limiting their exposure to specific cancer-causing agents and making wise lifestyle choices.

Overview

Students learn about the important functions of cells in maintaining homeostasis within the body. They discuss factors within the body and in the environment that affect the health of cells. Students explore two serious kinds of disorders resulting from cells that do not function normally-genetic diseases and cancer. They learn about DNA mutations and their different effects if they occur in somatic cells, as compared with mutations in gamete cells. Students investigate the cause of and treatments for cystic fibrosis, a single-gene disorder affecting the lungs and other organs of the body. They learn how cancer cells are different from normal cells, and they explore risk factors for cancer of the colon. In summarizing what they have learned about factors that affect cells, students identify ways to lower their risks of developing cancer in their lifetime.

Objectives

Students:

✓ identify factors that affect the health of cells.

✓ explain DNA mutations and their effects on somatic cells compared with gamete cells.

✓ describe how cancer changes normal cell function.

✓ identify ways to lower their risk of developing certain kinds of cancer.

Vocabulary

cancer, cystic fibrosis, mutation, stem cells, stroke, tumors.

Student Materials

Activity 5-1: Cells Gone Awry

- Activity Report
- Compound light microscope
- Prepared laboratory slides from blood, lung, or liver tissue

Teacher Materials

Activity 5-1: Cells Gone Awry

- Activity Report Answer Key
- Photographs, charts, diagrams, slides, or laserdisk images of normal and diseased tissue from blood, lung, or liver

Advance Preparation

See Activity 5-1 in the Student Edition.

Activity 5-1: Cells Gone Awry

- Allow ample time to order slides. A suggested resource for prepared slides follows:
  - Carolina Biological Supply Company Telephone: 1-800-334-5551
- Suggested slides:
- Human Pathology sets, contain variety of slides including normal/diseased or diseased only. Price range varies for 3-24 slides. e.g., D8-31-6986 Histopathology of Disease Set. 24 slides include normal and diseased tissues of the same organ. Give a general overview of some disease processes. Human pathology preparations can also be ordered separately from the Carolina catalogues.
- Other sources include slides from a local high school science department, hospital, clinic, or university research laboratory.
- Gather sufficient numbers of microscopes and slides for students to work in teams of two.

Interdisciplinary Connection

Health Education Arrange for a cytotechnologist, scientist, or physician from a research laboratory, clinic, or hospital to discuss the cellular basis of diseases such as cancer and cystic fibrosis.

6.2 Using The Health of Cells – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Emphasize that cells have important functions in maintaining homeostasis.

Discuss DNA mutations and genetic diseases.

Assign *Activity 5-1: Cells Gone Awry.*

Discuss information in Figure 5.1 on page 48 when discussing cystic fibrosis.

Emphasize Figures 5.2-5.5 on pages 49-51 as you discuss cancer.

Select appropriate Projects if time permits.

At the end of the section, refocus students' attention on the key ideas.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Explain how a mutation in a DNA molecule of only one base could cause a genetic disease in which an essential protein is altered so that it does not function normally. Make sure you explain how each step of protein synthesis is affected.

Apply Your KNOWLEDGE

What do you think happens to the cell cycle in a tumor cell (cancer cell)? You know that tumors can grow very fast. Is that because of changes in the cell cycle of an individual cancer cell or changes in the whole group of cancer cells? Do you think that a cancer cell goes through its cell cycle faster, slower, or at the same rate as a normal cell?

6.3 Activities and Answer Keys

Activity 5-1: Cells Gone Awry

PLAN

Summary Students use microscopes to compare the structure and appearance of cells from normal and diseased tissue. They identify structural differences and predict how these differences may affect tissue function.

Objectives

Students:

✓ compare normal and diseased tissue samples.

✓ identify structural differences in cells from diseased and normal tissue.

✓ predict how structural differences may affect normal function of the tissue.

Student Materials

- Activity Report
- Compound light microscope
- Prepared laboratory slides from blood, lung, or liver tissue

Teacher Materials

- Activity Report Answer Key
- Photographs, charts, diagrams, slides, or laserdisk images of normal and diseased tissue from blood, lung, or liver

Advance Preparation

Allow ample time to order slides. A suggested resource for prepared slides follows:

Carolina Biological Supply Company Telephone: 1-800-334-5551

Suggested slides:

Human Pathology sets, contain variety of slides including normal/diseased, or diseased only. Price range varies for 3-24 slides. e.g., D8-31-6986 Histopathology of Disease Set. 24 slides include normal and diseased tissues of the same organ. Give a general overview of some disease processes. Human pathology preparations can also be ordered separately from the Carolina catalogues.

Other sources include slides from a local high school science department, hospital, clinic, or university research laboratory.

Gather sufficient numbers of microscopes and slides for students to work in teams of two.

Estimated Time One to two class periods

Interdisciplinary Connection

Health Education Arrange for a cytotechnologist, scientist, or physician from a research laboratory, clinic, or hospital to discuss the cellular basis of diseases such as cancer and cystic fibrosis.

Prerequisites and Background

Students need to have knowledge of cell parts and their function. They also need to know the differences between somatic cells and gamete cells.

IMPLEMENT

Introduce Activity 5-1 by reminding students of the correct, safe procedure for using a microscope.

- First, set up the microscope with an appropriate light source. If using a microscope with a mirror, remind students not to point the mirror directly at the sun.
- Select the coarse adjustment and lowest power objective. *Watching carefully from the side,* lower the objective *carefully* until it barely reaches the surface of the prepared slide.
- Look through the eyepiece and use the fine adjustment to slowly draw the objective away from the slide to bring the specimen into sharp focus.
- Remind students that prepared slides require much time and expense to make. Therefore, students need to be very careful not to break them by moving the microscope objective onto the prepared slide.

Step 1 Prior to their observations and comparisons of the slides, discuss with students what is meant by differences in arrangement of cells, or the size of the nucleus as compared to the amount of cytoplasm. You may want students to review Section 1.

Steps 2-4 Depending on your supply of samples, you may have teams examining different tissues. If necessary, explain to students which tissue samples of normal and diseased specimens that each team is to examine.

Steps 5-6 Have students complete their Activity Reports. Monitor the cleanup and storage of the materials used. Monitor the return of the prepared slides and microscopes.

Helpful Hints

If students ask what a pathologist does, they can conduct research to discover the following information.

- A pathologist is a physician who interprets and diagnoses the changes caused by disease in cells and tissues. Pathologists send their reports to other physicians, such as surgeons, pediatricians, and oncologists (cancer specialists) to help them determine treatments for patients or to identify cause of death.
- Pathology is a specialized branch of medicine involving the essential nature of diseases, the disease process, and especially the structural and functional changes produced by them.
- Locations in a community where pathologists work include hospitals, forensic labs, research institutions, industry, diagnostic clinics, and medical practices.

Assess

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ identify structural differences in the appearance of cells from normal and diseased tissue samples.

✓ predict how structural differences in cells may affect tissue function.

Activity 5-1: Cells Gone Awry – Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Draw and label each normal tissue sample.
2. Draw and label each diseased tissue sample.
3. Select one tissue, and compare the normal and diseased samples. Describe the similarities and the differences in features such as cell size, shape, number, the arrangement of cells within the tissue, and the size of the nucleus compared to the amount of cytoplasm.
4. How would these diseased cells affect the normal function of this tissue or organ in the body?
5. From what you have learned in this unit, what factors might be responsible for a normal cell becoming diseased? Explain the processes involved.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What are mutations? Can they be harmful? Explain.
2. How can mutations be beneficial? Explain.
3. What can you do to reduce your risk of developing cancer? Explain.

Activity 5-1 Report: Cells Gone Awry (Student Reproducible)

1. Draw and label each normal tissue sample.

2. Draw and label each diseased tissue sample.

3. Select one tissue and compare the normal and diseased samples. Describe the similarities and the differences in features such as cell size, shape, number, the arrangement of cells within the tissue, and the size of the nucleus compared to the amount of cytoplasm.

4. How would these diseased cells affect the normal function of this tissue or organ in the body?

5. From what you have learned in this unit, what factors might be responsible for a normal cell becoming diseased? Explain the processes involved.

CHAPTER 7 Additional Resources Lives of Cells - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

7.1 Using GroupWork Activities

Learning science is a process that is both individual and social. Like researchers, engineers, mathematicians, or physicians who work in teams to answer questions and to solve problems, students in science classrooms often need to interact with their peers to develop deeper knowledge of scientific concepts and ideas. The GroupWork activities were developed to foster an environment in which groups of students work cooperatively to

- plan experiments,
- collect and review data,
- ask questions and offer solutions,
- use data to explain and justify their arguments,
- discuss ideas and negotiate conflicting interpretations,
- summarize and present findings,
- and explore the societal implications of the scientific enterprise.

The GroupWork environment is one in which students are "doing science" as a team. Suggestions about when to introduce these group activities are included in the Teacher Activity Notes.

Format and Organization of GroupWork Activities Each GroupWork activity includes teacher activity notes, an activity guide, an individual report, resource materials, and at times, data sheets. The activity guide contains instructions for the group's task and questions to be discussed as students plan for and work on a group product. Resource materials are varied. They might include textual information, visual resources such as photos, drawings, graphs or diagrams, video, or audiotapes. Individual reports by students are an integral part of each activity to be completed in class or as part of a homework assignment. Planning information for the teacher is found on the Teacher Activity Notes page.

Sets of GroupWork activities are organized around a central concept or a basic scientific question-a "big idea." Ideally, as students rotate to complete these activities, they encounter this central idea, question, or concept in different scientific contexts or in different social settings. These rotations provide students with multiple opportunities to grapple with the material, explore related questions and dilemmas, look at different representations, and think of different applications. Figure 1 shows how students rotate from activity to activity around the "big idea."

The GroupWork activities were designed to be open-ended to foster the development of higher-order thinking skills. Such open-endedness allows students to decide as a group how to go about completing the task, as well as what the final group product might be. Open-ended group activities increase the need for interaction as students serve as resources for one another, draw upon each other's expertise and knowledge, and take advantage of their different problem-solving strategies. When groups are heterogeneous and include students with many different intellectual abilities, the repertoire of strategies and previous experiences is rich and diverse. As students interact with their peers, they learn how to communicate effectively, justify their arguments when challenged, and examine scientific problems from different perspectives. Such interaction scaffolds students' knowledge of scientific concepts and principles.

These GroupWork activities then are quite different from traditional lab activities that include more step-by-step procedures and are crowded with details. In addition to reading, writing, and computing (the traditional academic abilities), students use many different intellectual abilities to complete their task. They make observations, pose questions, plan investigations; they use and create visual models, access and interpret scientific information from different sources and from different media, and convey scientific findings in diagrams, graphs, charts, or tables. The use of a wide array of resource materials provides students with additional ways to access and use information, as well as with additional opportunities to demonstrate their intellectual competence and be recognized for their contributions. We have included in the Teacher Activity Notes a partial list of some of the multiple abilities students

might be observed using in these group activities.

When group activities are open-ended, rich, and intellectually demanding, a single student will not be able to complete the task in a timely fashion by himself or herself. Making students responsible as a group to interpret a challenging task and to design a common product or group presentation increases group interdependence. Teachers know, however, that it is also important to hold each student personally accountable for contributing to the group's success and for mastering the concepts or the big idea of the activity. To do so, students are required to complete individual written reports in which they respond in their own words to key discussion questions and summarize what they have learned in the group activity. These written responses can be useful for teachers in gauging and monitoring student understanding and progress.

Role of the Teacher Planning ahead and organizing the classroom for GroupWork is important for the successful implementation of group activities. We suggest that you refer to Elizabeth Cohen's book, *Designing GroupWork: Strategies for Heterogeneous Classrooms*, published by Teachers College Press in 1994. (See also Lotan, R.A., J.A. Bianchini, and N. C. Holthuis (1996). "Complex Instruction in the Science Classroom: The Human Biology Curriculum in Action," in R. J. Stahl, (Ed.) *Cooperative Learning in Science. A Handbook for Teachers*, Addison-Wesley Publishing Company)

Many teachers have realized that when students work in groups, direct instruction is no longer practical. The teacher can't be everywhere at once, telling students exactly what to do and how to do it. Thus, teachers delegate authority to students and students take responsibility for their own behavior and their own learning. Rather than constantly turning to the teacher for help, students talk with each other to find out what they should be doing and to solve the challenging problems assigned to them. Teaching students to work collaboratively and to be responsible to one another as a group is an important prerequisite for successful GroupWork. Students also support the smooth operation of groups when they have learned to play different roles in their groups effectively. For example, the facilitator sees to it that everyone in the group knows what has to be done and gets help when necessary. The recorder keeps notes of the group's discussions and checks to see if individual reports have been completed. The materials manager sees to it that the group has all the equipment necessary and that the tables are cleared at the end of the lesson. The reporter presents the findings of the group during wrap-up time. When the activity involves hazardous materials, a safety officer might be needed. Every student must have a role to play, and roles rotate so students learn how to perform each role competently.

Delegating authority doesn't mean that the teacher Withdraws from the class or completely stays out of the action. Instead of being the focal point of the classroom, the teacher carefully observes the students as they work in the groups, stimulates and extends their thinking, and provides specific feedback.

Equalizing Participation among Members of the Group Making sure that all members of the group have access to the materials and that one group member doesn't take over or dominate the group while another withdraws are among the principal challenges of GroupWork. Teachers can increase participation of students by explaining how the different intellectual abilities are relevant to the successful completion of the task. The teacher states that while no one group member has all the abilities, everyone in the group has some of the intellectual abilities necessary to complete the task successfully. Furthermore, after careful observation of the students' work in groups, the teacher can publicly acknowledge those students who have made relevant contributions and explain specifically how these contributions made the group move forward and become more successful. It is important that the teacher be able to notice the intellectual contributions of students who have low academic or peer status, and who are frequently left out of group interactions. These strategies are particularly relevant in untracked classrooms, where students have a wide range of previous academic achievement (mainly in reading) or where significant proportions of students are English-language learners. Teachers, classmates, and the low-status students themselves need to understand that when many different intellectual abilities are necessary to complete a task successfully, everybody's contribution becomes critical to the success of the group. As more previously low-achieving students feel and are expected to be competent, their participation in the group increases, and subsequently their learning achievements increase as well.

Rachel A Lotan, Ph.D.

School of Education

Stanford University

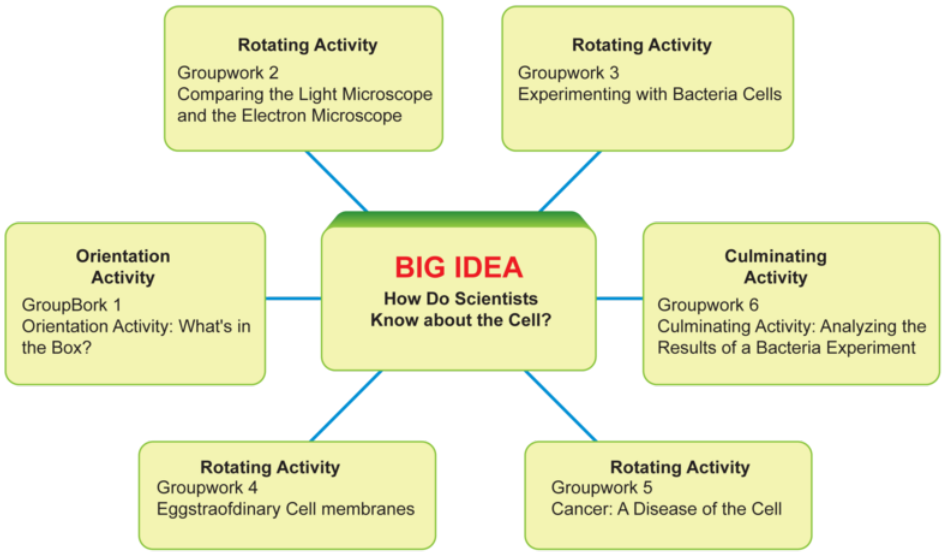


Figure 1 Activity Rotation in GroupWork

GroupWork Contents

TABLE 7.1:

Activity	Duration	Materials	Activity Summary
1. GroupWork 1 Orientation Activity: What's in the Box?	50 minutes	Sealed box with assorted items inside	This introductory demonstration requires students to consider the way in which people seek to learn about objects or events. The teacher must apply this to the cell-how to scientists know about the cell?
2. GroupWork 2 Comparing the Light Microscrope and the Electron Microscope	40 minutes	Microscope, microscope slides, cover slips, cheek (squamous epithelial) cells or prepared slides, methylene blue, and art supplies	Students use a light microscope to examine cheek cells. They compare the light microscope and the electron microscope by designing advertisement.
3. GroupWork 3 Experimenting with Bacteria Cells	50 minutes	2 petri dishes with agar and bacteria, and any of the following: antibiotic discs, refrigerator, ultraviolet light source, salt, sugar, vinegar	Students design an experiment to determine the effects of various factors on bacterial cell growth and reproduction. They develop procedures for conducting the experiment and methods for data collection.

TABLE 7.1: (continued)

Activity	Duration	Materials	Activity Summary
4. GroupWork 4 Eggstraordinary Cell Membranes	50 minutes	4 eggs with dissolved shells (one in air, one in colored water, one in corn syrup, one in vegetable oil), art supplies	Students examine two eggs without shells to learn about the structure and function of cell membranes. They are asked to create a model of a cell membrane.
5. GroupWork 5 Cancer: A Disease of the Cell	40 minutes	None	Students examine resource materials on cancer. They are asked to refute of defend a legal case that relates the incidence of cancer to one or more risk factors.
6. GroupWork 6 Culminating Activity: Analyzing Results of a Bacteria Experiment	40 minutes	2 petri dishes with agar and bacteria from GroupWork Activity 3, art supplies (such as markers, poster paper, cardboard), costumes, and props	Students observe bacteria, analyze the results of bacterial cell growth, and present their findings on the factors affecting their growth.

GroupWork 1: Teacher Activity Notes - Orientation Activity: What's in the Box?

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

Students participate in a demonstration that requires them to consider the ways in which people seek to understand objects or events. Students are then asked to apply this to the cell: how do scientists know about the cell? NOTE: There is no student activity card for this activity.

Group Size 4 to 5 students

Objectives

Students:

- identify an unknown object using indirect evidence and observations.
- predict how scientists study objects like cells without seeing them with the naked eye.

Multiple Abilities

- Observing carefully, recording data correctly and clearly (ability to be precise)
- Explaining clearly and fully, using words precisely (communication skills)

Student Materials

- A closed wooden or cardboard box that contains one or two somewhat familiar but not necessarily commonplace objects (e.g., an egg beater, a computer diskette, or part of a machine)

Estimated Time 50 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Tell students that you have found this box in your attic, and you want to find out what is in it. However, you can't get it open! Divide students into groups and brainstorm ways to find out what is in the box.

2. Have students select a reporter in each group. Allow students to discuss methods for finding out for 3 to 5 minutes. Have reporter from each group share the group's responses. As they come up with ideas, write them on the chalkboard, grouping them by method. Add any other ideas that students didn't think of themselves such as the following:

- Shake it and make some assumptions based on the noise.
- Use technology, such as an X-ray or stethoscope.
- Conduct a controlled experiment. For example, if I think it's a particular object, I could create a similar apparatus with known objects and then compare such characteristics as weight, movement, and sound.

3. After each group reporter reports the group ideas, explain that scientists often can't use a textbook that has all the answers in it when they are studying something. Rather, they have to analyze different pieces of evidence carefully and then make conclusions. Emphasize that science is not simply a collection of facts or beliefs, but of interpretations of evidence. Compare the methods a scientist might use to study cells (observations, technology, and empiricism) with the suggestions given by students to determine the contents of the box.

Background Information

None required

Extend This Activity

Ask students to design an experiment or new technology that would help them determine what is in the box, as scientists have done to study the cell in greater detail. Compare this to the exchange of ideas between science and technology in the study of cells.

Extension Questions

How does the analogy of a cell as a box that cannot be opened accurately represent how scientists study cells? How is it *not* a good comparison?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- observe carefully and use indirect evidence to identify an unknown object.
- explain their predictions based on concrete observations or indirect evidence.
- predict, using the analogy of the unknown object in a box, how scientists often use various kinds of evidence to study cells.

GroupWork 1 Individual Report: Orientation Activity: What's in the Box? (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. Describe at least three methods one could use to determine what is in the box.

2. a. What evidence will these methods provide?

b. What questions will you still have after using these methods?

GroupWork 2: Teacher Activity Notes - Comparing the Light Microscope and the Electron Microscope

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

Students use a light microscope to examine cells and then analyze information about the electron microscope. They compare the uses and advantages of each type of microscope by designing catalog advertisements for a scientific supply company.

Group Size 4 to 5 students

Objectives

Students:

- identify cells and nuclei using a light microscope.
- explain reasons for using both light microscopes and electron microscopes to study cells.

Multiple Abilities

- Observing carefully, recording data correctly and clearly (ability to be precise)
- Making detailed and lifelike drawings (artistic ability)
- Creating an engaging and influential presentation (creative ability)
- Explaining clearly and fully, using words precisely (communication skills)

Student Materials

- Microscope, microscope slides, cover slips, cheek (squamous epithelial) cells or prepared slides, methylene blue, poster paper, colored pens or pencils

Estimated Time 50 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Before beginning this activity, remind students of the proper handling and use of the light microscope. Remind students that they should not point the mirror directly at the sun. Make sure that they know how to prepare a

wet-mount slide by placing their sample onto the slide, adding a drop of methylene blue, mixing it with the toothpick, and covering it with the slip cover. They need to focus the microscope on low power first, then medium and high powers.

2. If you do not wish students to prepare slides of their own cheek cells, have prepared slides on hand for them to use. Examples of prepared slides include erythrocytes, lymphocytes, sperm, eggs, cardiac muscle, and neural retina.
3. It is important for students to see that the field of view changes as the magnification changes, allowing us to see either the "big picture" with little detail at the lowest power or much greater detail with a smaller field of view at the highest power. At low power, many small clumps of cells may be visible because of the large field of view. At medium power, cells will appear larger, and there will be fewer of them due to the reduced field of view. Nuclei within each cell may appear as darker spots. At high power, probably only one or two clumps of cells will be visible, with the dark nuclei clear within each cell. The double-layered cell membrane may also be visible.

Background Information

The naked, human eye cannot see most eukaryotic cells. They are too small-between 10 and 30 micrometers in diameter. Why can't we see such small objects? The answer lies in the physiology of the eye. If two objects are farther apart than 100 micrometers, the light beams that are reflected from the objects into the eye fall on different detector cells (rods or cones) in the retina. Thus, the eye is able to resolve the two objects-to tell that there are two objects instead of one. However, if the two objects are closer together than 100 micrometers, the light beams fall on the same detector. We then see only one object.

In order to distinguish individual cells, to say nothing of their structures, humans must use instruments that provide greater resolution. Resolution is defined as the minimum distance that two points can be separated and still be seen as two points. One way to increase resolution is to increase magnification-to use microscopes. Indeed, most of our current knowledge about cell structure has been gained through use of microscopes.

Three centuries ago, Robert Hooke and Antonie von Leeuwenhoek used simple, light microscopes to magnify the size of cells so that the cells appeared larger than 100 micrometers. These simple microscopes magnified images of cells by bending light through a single glass lens. Leeuwenhoek's microscope, for example, consists of (1) a plate with a single lens, (2) a mounting pin that holds the specimen to be observed, (3) a focusing screw that moves the specimen nearer to or farther from the eye, and (4) a specimen-centering screw. Although simple in construction, this type of microscope provides a magnification of 266 times, as good as many modern microscopes. It makes visible structures that are less than 1 micrometer (100 nanometers) in thickness.

To learn how a simple microscope works, examine the figures below. The size of the image that falls on the retina depends on how close the object is to the eye-the closer the object, the bigger the picture. The eye, however, is not able to focus comfortably on an object closer than about 25 centimeters; it is limited by the size and thickness of its lens. A glass lens interposed between the object and eye, as in a simple microscope, provides additional focusing power. Because the object is closer, the image on the back of the eye is bigger than it would have been had the object been 25 centimeters away from the eye. As a result, we perceive the object as magnified.

Extension Questions

- How did the invention of the light microscope influence scientific knowledge and practice?
- Define science and technology. What is the relationship between the two? What evidence can you provide for this relationship?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- identify cells and nuclei using the light microscope.

- observe and explain structural differences in various cells.
- explain the benefits of the advanced technology of the electron microscope.
- describe the use of each kind of microscope.
- explain why and how scientists might use one or the other kind of microscope to study cells.

GroupWork 2 Activity Guide: Comparing the Light Microscope and the Electron Microscope (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Introduction

One of the first important sources of information about cells came from the light microscope. As technology improved, the electron microscope was developed to study cells in a different way. In this activity you consider the relative usefulness of these two tools.

Materials

- Microscope
- Microscope slides
- Cover slips
- Cheek (squamous epithelial) cells or prepared slides
- Methylene blue
- Art supplies such as poster paper, colored pens, or pencils

Procedure

Step 1 Working in *pairs*, use the microscope to examine a sample of epithelial cells (from the inside of a person's cheek). First, prepare the slide and add a drop of methylene blue to the slide. On your Data Sheet, make a diagram of your observations when using the microscope on low, medium, and high powers.

Step 2 As a group, discuss the following question. What are the differences in the field of view when using the microscope at low, medium, and high powers?

Step 3 Compare and contrast the diagrams of the cells under a light microscope on Resource 1 with the diagrams you created.

Step 4 Examine the information about the electron microscope on Resource 2. In your opinion, why and how do scientists use both kinds of microscopes (light and electron)?

Step 5 Your group is the advertising team for a scientific supply company, and you need to develop an advertisement for both the light microscope and the electron microscope. Make sure to include the following in your advertisement.

- A description of the use of each kind of microscope.
- Why and how scientists might use one or the other kind of microscope to study cells.
- An explanation of the benefits of the advanced technology of the electron microscope.

GroupWork 2 Data Sheet: Comparing the Light Microscope and the Electron Microscope (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

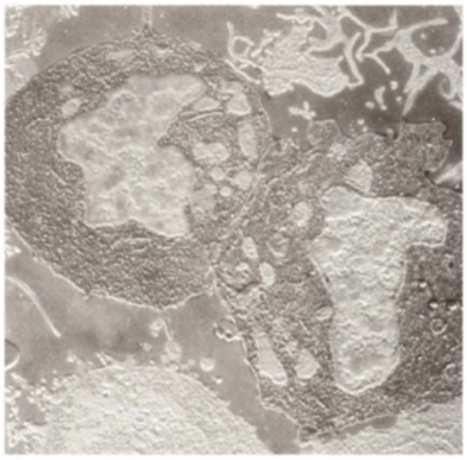
1. Diagram of cells at Low Power

2. Diagram of cells at Medium Power

3. Diagram of cells at High Power

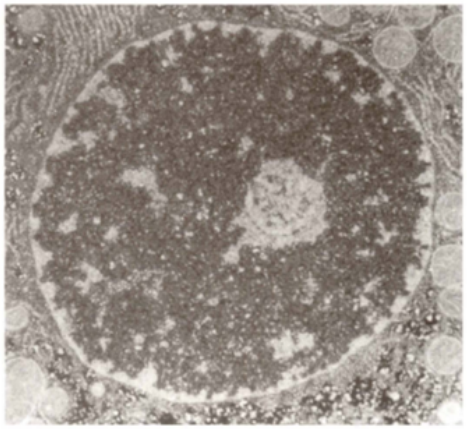
GroupWork 2 Resource 1: Comparing the Light Microscope and the Electron Microscope (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

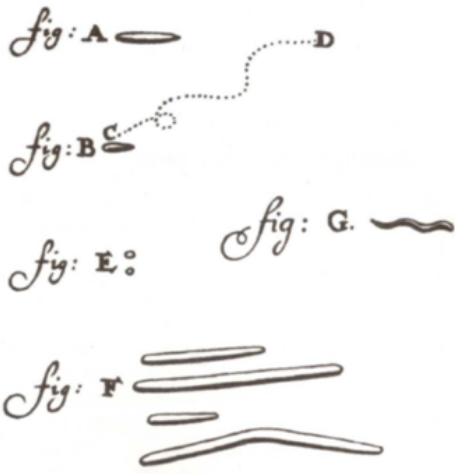


Cell during cell division (mitosis).

Fertilization of a human egg.



Section of a cell.



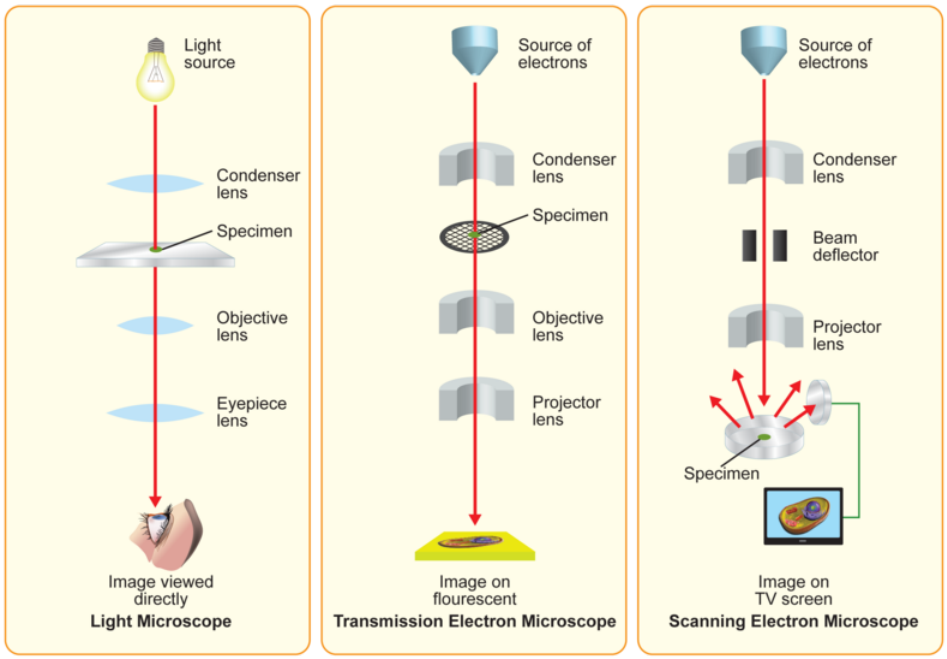
Leeuwenhoek's drawing of one-celled "Animalcules" from one of the first light microscopes.

GroupWork 2 Resource 2: Comparing the Light Microscope and the Electron Microscope (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Brief Discussion of Electron Microscopes

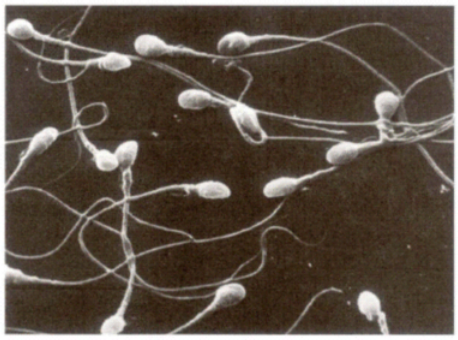
There are two kinds of electron microscopes. The first kind is called the **transmission electron microscope.** Transmission electron microscopes use electrons transmitted through the material being observed to visualize the specimen. The specimen is prepared as a very thin section. Areas of the specimen that permit the transmission of many electrons, called electron-transparent regions, show up bright. Areas that scatter electrons away from the image, called electron-opaque regions, appear dark. Transmission electron microscopes are capable of resolving objects only 0.2 nanometers apart, or five times the diameter of a hydrogen atom!



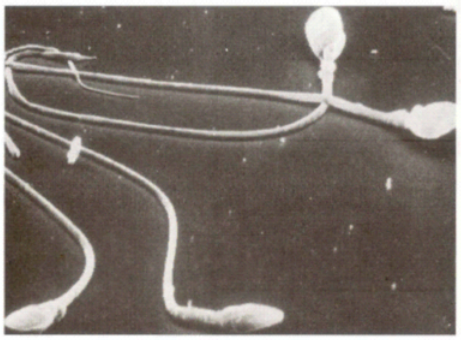
A second kind of electron microscope, the **scanning electron microscope,** produces striking three-dimensional (3-D) images. A beam of electrons works like a fine probe to focus on the surface of the specimen, which passes back and forth rapidly. The electrons that are reflected back from the surface of the specimen, together with other electrons that the specimen itself emits, are amplified and transmitted to a television screen. There, the image can be viewed and photographed. In images made with a scanning electron microscope, depressed areas and cracks in the specimen appear dark, while elevated areas such as ridges appear light. Although scanning electron microscopes have a resolution of only 10 nanometers, they have proven to be very useful in observing and learning about many biological and physical phenomena.

There are two major drawbacks of the electron microscope. First, cells are killed in the process of preparing them for examination. Thus, the movements and reactions that occur in living cells remain largely invisible. Second, the preparation of cells for the electron microscope often damages cell structure. In other words, what is seen may differ from what is actually present in a living cell.

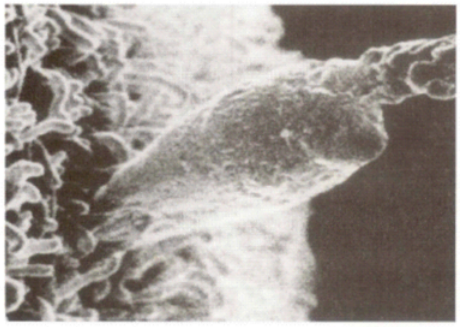
7.1. USING GROUPWORK ACTIVITIES



Light microscope.



Transmission electron microscope.



Scanning electron microscope.

GroupWork 2 Individual Report: Comparing the Light Microscope and the Electron Microscope (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. How did you go about examining cheek cells under the light microscope? What did you learn from this process?

2. What are the differences in using a light microscope versus an electron microscope to study cells?

3. What does the use of electron microscopes in scientific research say about the relationship between science and technology?

GroupWork 3: Teacher Activity Notes - Experimenting with Bacteria Cells

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

Students design and implement scientific experiment to determine the effects of various factors on bacterial cell growth and reproduction.

Group Size 4 to 5 students

Objectives

Students:

- design an experiment to determine the effects of various factors on bacterial cell growth and reproduction.

- develop procedures for conducting the experiment and methods for data collection.

Multiple Abilities

- Logically analyzing the problem, making connections between ideas/concepts, solving a problem experimentally, making a hypothesis (reasoning ability)
- Explaining clearly and fully, using words precisely (communication skills)

Student Materials

- Resource
- Individual Report
- 2 petri dishes with agar and bacteria, and any of the following: antibiotic discs, refrigerator, ultraviolet light source, salt, sugar, vinegar, magnifying glass or microscope

Estimated Time 50 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. To prepare for this activity, pour the agar plates or purchase petri dishes with the nutrient agar already inside. For instructions on preparing and pouring agar, see the manufacturer's suggestions. You need 12 petri dishes, each with 25 ml of agar so each group can have its own control and variable specimens.
2. Before students begin this rotation of activities, you may want to brainstorm as a class how students could gather data for this experiment and how they would quantify their data. They could make a grid on the petri dish and count how many colonies (spots) they see in each grid, or they could estimate the percentage of the dish that is covered with bacteria colonies.
3. Students will be designing and setting up their experiment during this activity. Make sure they give you an opportunity to review and approve their experimental design before they implement it. Due to the duration of bacteria growth, they will be analyzing their results during the Culminating Activity. Since groups will have started the experiment on different days, you can use the various amounts of growth as a point of discussion and analysis during the final activity.
4. When students are choosing the variable with which to experiment, make sure mat each group chooses a different variable (sun versus darkness, warm versus cold, dry versus humid) so that you can have rich discussions about many factors that affect bacteria growth.
5. Remind students that they must keep their petri dishes closed at all times during the experiment, as any contamination from bacteria in the air will affect their results.

Background Information

None required

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- state the research question.
- predict the experimental results and give reasons for their predictions.

- describe and justify me experimental procedures.
- identify a "control" for their specific experiment.
- explain the methods for data collection and recording.

GroupWork 3 Activity Guide: Experimenting with Bacteria Cells (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Introduction

Scientists have gained knowledge of the structure and function of cells in a number of different ways. Sometimes, they might simply observe a live cell under a light microscope or a prepared cell under an electron microscope. Other times, they design experiments by changing the cell or its environment and studying the effects. In this activity you are the Research Team for a biotechnology company interested in using bacteria to develop a new drug. You need to know what the best conditions for cell growth are in order to manufacture the drug.

Materials

- Resource
- Individual Report
- 2 petri dishes with agar and bacteria
- Magnifying glass or microscope
- Other materials will vary based on experimental designs.

Procedure

Step 1 Discuss with your group the following questions and record your responses.

- What environmental factors could you change in the lab in order to test their effect on bacteria cell growth?
- In making observations of bacteria in petri dishes, how would you know whether the cell growth was affected? What changes would you look for? How would you display your data?

Step 2 Based on the materials provided by your teacher, design an experiment to test the effects of one of the factors on your list. Write your final experimental design on the Resource. Make sure you list the Materials, the Procedure, and any questions you want to answer. Get your teacher's approval of your experimental design, then use the materials to set up the experiment in the area designated by your teacher. You will have to wait for one or more days for your cells to grow, then you can analyze the results of your experiment during the Culminating Activity.

Your product for this activity is a proposal and presentation to the president of the company that describes your experiment and includes

- an explanation of your research question.
- what you predict this experiment will prove.
- the procedure you used to set up the experiment and why you did it that way.
- how you will collect your data.

GroupWork 3 Resource: Experimenting with Bacteria Cells (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Use this sheet for your final experimental design to test the effects of your selected factors on bacterial cells. Remember to get your teacher's approval of your experimental design before you implement it.

GroupWork 3 Individual Report: Experimenting with Bacteria Cells (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. How did your group decide what environmental factor from your list you would test on bacteria cell growth?

2. What do you think your experiment will demonstrate about cell growth?

3. Why are you using nutrient agar in the petri dishes to grow your bacteria cells? What does this tell you about the requirement for living cells?

GroupWork 4: Teacher Activity Notes - Eggstraordinary Cell Membranes

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

Students observe eggs without shells in various substances to determine what molecules can pass through a cell membrane. They design and construct a model of the cell membrane structure.

Group Size 4 to 5 students

Objectives

Students:

- identify ways that molecules move into or out of the cell.
- describe the movement of molecules through the cell membrane.
- explain why the selective permeability of the membrane is important for the functioning of the cell.

Multiple Abilities

- Logically analyzing the problem, making connections between ideas/concepts, hypothesizing (reasoning ability)
- Observing carefully and accurately, recording observations correctly and clearly (ability to be precise)
- Drawing an idea, creating a model (spatial/visual ability and creative/artistic ability)

Estimated Time 50 minutes

Suggested Use

- This set of activities works well near the end of the unit.

Student Materials

- Data Sheet
- Individual Report
- *Lives of Cells* Section 3, *Cell Activities*
- 4 eggs with shells dissolved soaked in each of the following: vegetable oil, corn syrup, tap water with food coloring, dry in a closed container; coffee filters; strainer/colander; various small objects such as beans, sand, gravel; water; paper and colored pens or pencils

IMPLEMENT

1. Preparing the eggs: Begin preparing the eggs about 3 days before you plan to implement the activity. To dissolve the shell of the eggs, place them in about 2 cups of vinegar for approximately 48 hours. At the end of 48 hours, rinse the eggs with water. Then place half of them in colored water for 24 hours. Place the other half in an empty or water-filled container and cover it. We suggest making some extras, as a few are bound to break.
2. To transport the eggs safely to school, you may want to carry them in a zip-lock bag filled with water or vinegar. (The fluid will help cushion any blows the eggs may sustain in the course of the trip.) Place the bag or bags in another sealed, plastic or glass container.
3. You may provide students with an inexpensive, hollow rubber ball commonly found in supermarkets and drugstores. These balls can be used by students to help model a cell membrane.

Background Information

Cell membranes are freely permeable to water. Water molecules can pass through pores in the sheet of lipid molecules. They do so through the process of diffusion-water molecules move from an area of higher concentration to an area of lower concentration. This form of diffusion, involving net water movement across a membrane, is called osmosis.

Cell membranes, however, are not permeable to all molecules. Rather, they are selectively permeable. Selective permeability allows the passage across a membrane of some molecules but not others. It is the result of specific protein channels extending across the membrane. A selectively permeable membrane is important in that it allows the cell to act as an isolated compartment. Thus, a cell can concentrate and/or bring together these molecules it needs to survive.

There are two ways that channels in cell membranes move molecules into and out of the cell. They are *facilitated diffusion* and *active transport*. Facilitated diffusion is the transport of molecules across a membrane by specific channels toward the direction of lowest concentration. Active transport is the transport of a molecule across a membrane, independent of the concentration, by the expenditure of chemical energy.

Extend This Activity

Ask students to brainstorm other substances they could put the shell-less egg into to find out what molecules will cross the cell membrane, then have them try it at home or in class.

Extension Questions

- What other ways can molecules move into and out of the cell?
- What purpose does a selectively permeable membrane serve?
- Why is it important for scientists to learn how cell membranes work? Provide a real-life example.

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- identify ways for molecules to move into or out of the cell (diffusion and active transport).
- describe how some molecules pass through the membrane, while others are excluded from either the inside or outside of the cell.
- explain why the selective permeability of the membrane is important for the functioning of the cell.

GroupWork 4 Activity Guide: Eggstraordinary Cell Membranes (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Introduction

Scientists often try to learn how cells work by studying the structure and function of their parts. To do so, they often conduct experiments to see how different conditions affect a cell. In this activity, you observe a single cell that's easy to see without a microscope: a chicken egg!

Materials

- Data Sheet
- Individual Report
- *Lives of Cells* Section 3, *Cell Activities*
- 4 eggs with shells dissolved soaked in each of the following: vegetable oil, corn syrup, tap water with food coloring, dry in a closed container Coffee filters
- Strainer/colander
- Various small objects such as beans, sand, gravel
- Water
- Paper and colored pens or pencils

Procedure

Step 1 On your Data Sheet, record your observations of the eggs and the substances in which they are soaking. How are they different? How are they similar?

Step 2 In your group, discuss the following questions.

- Based on your observations, which substances or molecules do you think can cross the cell membrane? How do you know? Consider the molecules that are inside and outside of the egg.
- How does an experiment like this help scientists learn about the structure of cells and cell membranes?

Step 3 Design and build a model to represent the cell membrane you have observed. Use your model to answer the following questions.

- How do some molecules pass through the membrane, while others are excluded from either the inside or the outside of the cell?
- What is the importance of the selective permeability of the cell membrane for the cell to function effectively?

GroupWork 4 Data Sheet: Eggstraordinary Cell Membranes (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Diagram and describe your observations about the differences and similarities between the eggs.

GroupWork 4 Individual Report: Eggstraordinary Cell Membranes (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. What was the purpose of having a shell-less egg that wasn't in any substance but air?

2. Draw a picture of your model of a cell membrane.

3. How does an experiment like this help scientists understand cells?

GroupWork 5: Teacher Activity Notes - Cancer: A Disease of the Cell

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

Students examine resource materials that deal with cancer and several environmental factors. They use these materials to defend or refute a legal case that relates the incidence of cancer to one or more of these factors.

Group Size 4 to 5 students

Objectives

Students:

- identify factors that cause cancer.
- describe how cancer cells move and change in the body.
- interpret graphs correlating incidence of cancer in various populations to environmental factors.
- analyze data to determine whether or not it proves causation for cancer.
- critique information to form arguments on a legal case.

Multiple Abilities

- Logically analyzing an issue, hypothesizing, making connections between ideas and concepts (reasoning ability)
- Analyzing and interpreting graphs (spatial/mathematical ability)

Student Materials

- Activity Guide
- Resources 1 and 2
- Individual Report

Estimated Time 40 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Discuss what students may already know about cancer. Have students use the text as a resource for explaining how cancer cells develop and move throughout the body.
2. The resources are a series of graphs showing strong correlations between various types of cancers and their risk factors. However, this is a good opportunity for students to learn the distinction between correlation and causation. In developing their product, a legal case, they may decide that more evidence is needed that shows the actual mechanism for the risk factor affecting cells, making them cancerous. On the other hand, students may decide that they already know enough about how cells work and the environmental factors in question to make a statement about causation.

3. Encourage each group to focus on a different risk factor or kind of cancer so that a variety of evidence is presented to the class.

Extension Questions

- How can knowing how cells are able to function help scientists develop treatments and/or cures for cancer?
- What are other examples of diseases caused by abnormal cells?
- What are ways to reduce your risk of cancer?

ASSESS

Use the group discussion, individual reports, and group product to assess if students can

- identify factors that cause cancer.
- describe how cancer cells move and change in the body.
- interpret graphs correlating incidence of cancer in various populations to environmental factors.
- distinguish between a correlation and a causation.
- analyze data to determine whether or not it proves causation for cancer.
- suggest what information is missing that could strengthen the argument or enhance the evidence.
- explain *evidence* for the risk factor that causes a specific type of cancer.

GroupWork 5 Activity Guide: Cancer: A Disease of the Cell (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Introduction

Scientists often perform experiments on or conduct studies of cells. For example, scientists explore how cancer cells grow, reproduce, and spread to learn more about cancer. They also attempt to determine what factors cause cancer. In this activity you discover a practical reason scientists study cells.

Procedure

Step 1 Examine Resource 1. In your group, discuss the following questions.

- What is the relationship between smoking and lung cancer for men and women in the United States over time?
- Using your text as a resource, what might be an explanation for this relationship?

Step 2 Examine Resource 2. In your group, discuss the following questions.

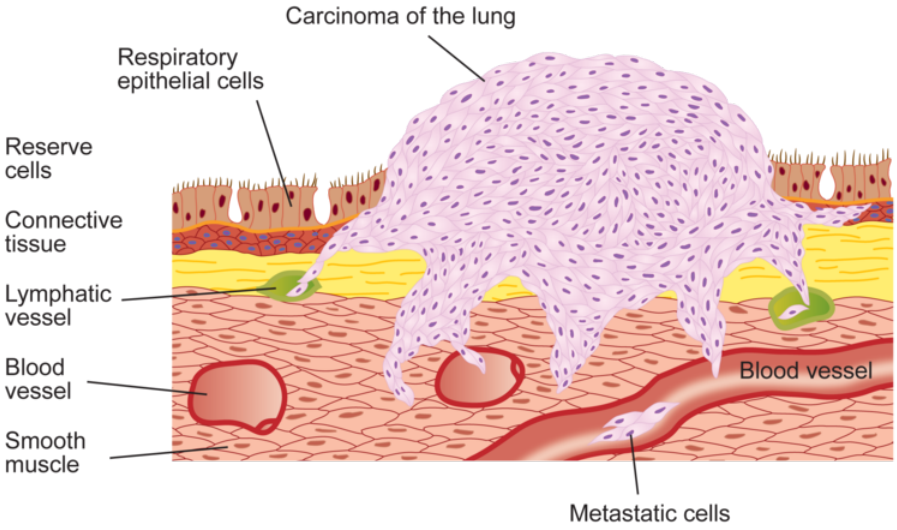
- What is the relationship between certain food consumption and cancer in countries around the world?
- What is the relationship between locations in the United States and the incidence of cancers? What aught be an explanation for this relationship?

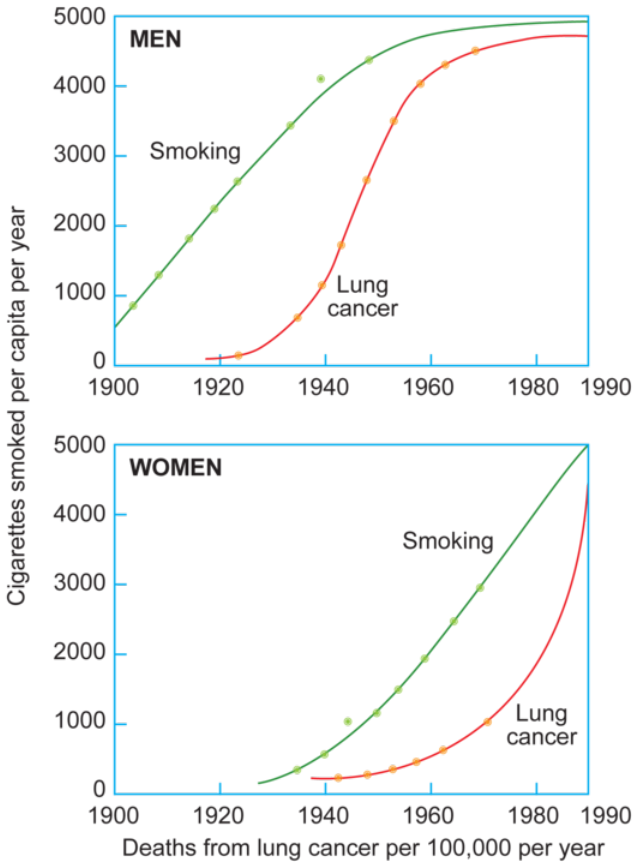
Step 3 Currently, cigarette companies are required to put warning labels that smoking is related to lung cancer on all packaging and advertisements. Should other factors related to cancers have warning policies as well? Your team must create a Public Information Campaign FOR or AGAINST a law that would require warning labels on any product that is shown to have a strong causal relationship with cancer. Be sure your presentation includes

- a description of how cancer cells move and change in the body,
- an explanation of your *evidence* for the risk factor you believe causes a particular kind of cancer, and
- a description of further studies you think could be done to prove more conclusively that this factor causes cancer.

GroupWork 5 Resource 1: Cancer: A Disease of the Cell (Student Reproducible)

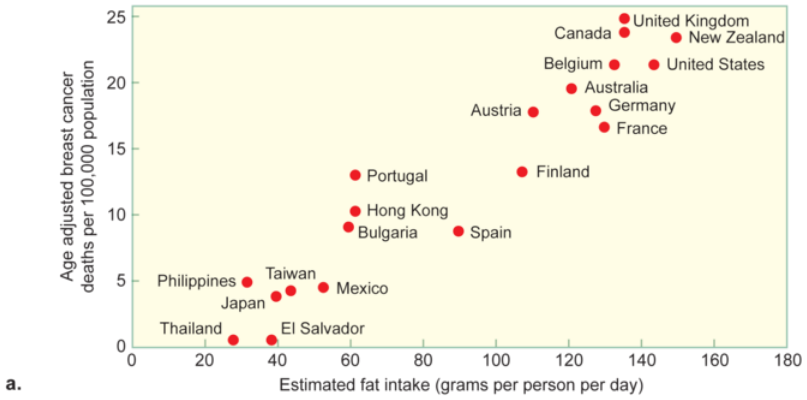
Big Idea: How Do Scientists Know about the Cell

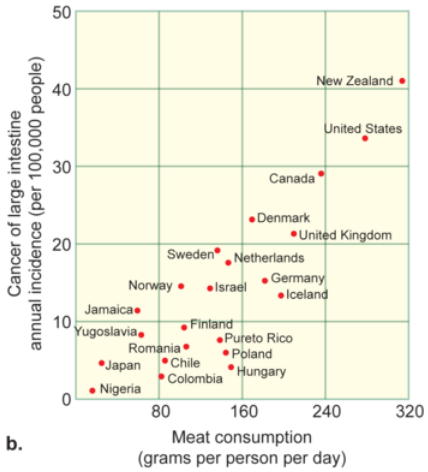


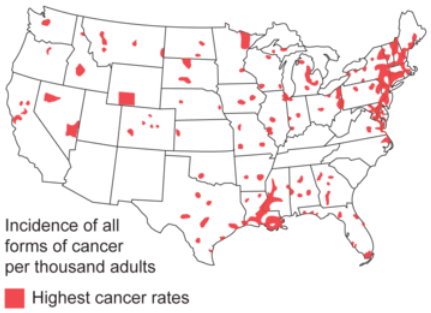


GroupWork 5 Resource 2: Cancer: A Disease of the Cell (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?







GroupWork 5 Individual Report: Cancer: A Disease of the Cell (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. How does cancer seem to operate in the body?

2. How can we identify factors that cause cancer?

3. How does this activity help answer the question: How do scientists know about the cell?

4. Briefly describe your team's case or explanation of the connection between the evidence presented and your client's cancer.

GroupWork 6: Teacher Activity Notes - Culminating Activity: Analyzing the Results of a Bacteria Experiment

Big Idea: How Do Scientists Know about the Cell?

PLAN

Summary

7.1. USING GROUPWORK ACTIVITIES

Students observe bacteria, analyze the results of bacterial cell growth, and present their findings regarding their experiment with factors affecting the growth of bacteria.

Group Size 4 to 5 students

Objectives

Students:

- conduct an experiment to determine which factors affect the growth of bacteria.
- collect data and graphically represent the results of their experiment.

Multiple Abilities

- Clearly and logically explaining to others how and why scientists study cells (communication skills).
- Making connections between ideas/concepts, logically analyzing the problem, solving a problem experimentally, making a hypothesis (reasoning ability).
- Recording data correctly and clearly, measuring accurately, explaining clearly and fully, observing carefully and accurately (ability to be precise).

Student Materials

- Data Sheet
- Individual Report
- 2 petri dishes with agar and bacteria from GroupWork Activity 3
- Art supplies, such as markers, poster paper, and cardboard; Costumes and props

Estimated Time 40 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

Students have experimented with different variables over a period of time. Therefore, be sure to discuss the differences between student results with respect to both the time that has elapsed since they set up the experiment and the different variables they tested.

Extension Questions

- Since the 1960s, most biological research has focused on molecular and cellular phenomena. Why do you think this is the case?
- How can knowledge about cells be used to learn how the human body works?

ASSESS

Use the group discussion, individual reports, and group product to assess if students can:

- make accurate observations.
- collect data and graphically represent the results of their experiment.
- explain the differences and similarities between the two petri dishes.
- recommend methods the Drug Development Team should use in growing bacteria in the lab, and/or methods they should not use.

GroupWork 6 Activity Guide: Culminating Activity: Analyzing the Results of a Bacteria Experiment (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Introduction

When experimenting with cells, scientists must make careful observations and analyze the results in order to make conclusive statements about cell growth. Your team designed and set up an experiment to study how a particular environmental factor affects the growth of bacteria. What conclusive statements can you make about cells based on what you observe in your own experimental results?

Materials

- Data Sheet
- Individual Report
- 2 Petri dishes with agar and bacteria from GroupWork Activity 3
- Art supplies, such as markers, poster paper, and cardboard Costumes and props

Procedure

Step 1 Obtain your group's petri dishes containing bacteria growing on agar. Record your observations of both petri dishes on the Data Sheet, paying attention to both the overall appearance as well as the *quantity* of growth of the bacteria culture.

Step 2 Record and compare the amount of bacteria growth in the two petri dishes. Display your quantitative data in a histogram (bar graph).

Step 3 Your team must now present your findings to the leaders of your biotechnology company. They want to know what factors affect cell growth in order to develop a new drug using bacteria. Make sure your presentation includes:

- the data and graph that shows the results of your experiment.
- an explanation of the differences and similarities between the two petri dishes.
- your recommendations about what methods the Drug Development Team should use in growing bacteria in the lab and/or methods they should not use.

GroupWork 6 Data Sheet: Culminating Activity: Analyzing the Results of a Bacteria Experiment (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

Record your observations on this sheet. Design any tables and/or graphs that help report the results of your experimental design.

GroupWork 6 Individual Report: Culminating Activity: Analyzing the Results of a Bacteria Experiment (Student Reproducible)

Big Idea: How Do Scientists Know about the Cell?

1. Based on all the activities in this unit, briefly explain all the ways scientists learn about cells.

2. What are at least three practical benefits of cell research?

3. What improvements would you make to your lab procedure if you could do this experiment again, and why?

4. What remaining questions do you have about how scientists study cells? Where could you find answers to these questions?

7.2 Projects

The following Projects are an assortment of long-term activities that can be completed individually, in groups, or as a class. We have provided starting points for research and development; you and the students can work together to create a more detailed plan of action. Consider the following two recommendations. First, because of the amount of work involved in a project, students should choose one of great interest to them. Second, to encourage excellence and promote student-student learning, students should present their finished projects to the rest of the class, to the school and to the community, if appropriate.

Project 1: Research Questions and Action Projects

Project 1 differs from the others: it is a list of possible research topics organized according to some key ideas and addressed to students.

In assigning a Research Question or Action Project, we ask that you allow students to choose their topic-either one provided or one of their own. You might also:

1. Specify length of piece.
2. Make clear the purpose and the audience.
3. Suggest sources and ideas for information.
4. Provide in-class time for compiling information and writing.
5. Require students to exchange papers and provide written feedback.
6. Provide a breakdown of due-dates for the following stages: choice of topic, outline, rough draft, and final draft.
7. Permit students to supplement a written report with a skit, a piece of artwork, a piece of music, a dance, a video, or a multimedia presentation.

ASSESS

Provide students with evaluation criteria that include

- accuracy of the content based on guiding questions.
- clarity of writing.
- effective organization of main ideas.
- use of detailed examples or citing evidence to support their conclusions.

Projects 1: Teacher Activity Notes - Research Questions

The following Research Questions require independent research. They are organized according to some key ideas and phrased in the form of a series of questions.

Cells Are the Basic Unit of Life A major concept in biology is the cell theory. What is the cell theory? Which scientists contributed to its development? How does the theory influence how we study biology today, frame research questions, plan methods, and analyze results?

Who were some early cell biologists? What methods did they use to study cells? How do these methods compare to those we use today? Before the work of these early scientists, what did people believe living things were made of?

The study of plant cells was an important precursor to the study of animal cells. What structural similarities allowed scientists to make comparisons between plant and animal cells? What microscope studies might you perform to observe the similarities and differences between plant and animal cells?

Environmental Factors Can Cause Mutations in DNA UV, or ultraviolet, light causes mutations, or changes in the DNA sequence, which in turn may cause cells to function and grow abnormally. What does exposure to the sun's UV rays do to your skin cells? Why do some people get sunburned and others get tanned? Can a person who tans and never burns still get skin cancer? What factors, if any, increase a person's risk of getting skin cancer? How does wearing sunscreen protect you when you are in the sun?

Proteins Make Individual Cells and Whole Organisms Unique If all the cells in a living organism have the same DNA, why do they look different from each other? For example, what makes a bone cell different from a liver cell? What types of proteins might a bone cell make that make it different from a liver cell? In what ways do cells adapt their structures to perform their specialized tasks?

Cells Recognize Other Cells by the Surface Proteins on the Cell Membrane What is an autoimmune disease? Why do many medical scientists believe multiple sclerosis is an autoimmune disease? What does multiple sclerosis do to the body? What type of research is underway to treat multiple sclerosis?

Staying Healthy Insulin is a protein produced by cells in your pancreas. It plays a critically important role in cell metabolism throughout your body. What does insulin do? What happens when your body cannot produce insulin? How has science been able to help people who cannot produce their own insulin?

Warts are caused by a virus that causes skin cells to behave abnormally. What does the virus do to alter cell functions? What can you do to counteract the virus' effects?

Exercise can change the appearance and size of muscles. How does regular exercise affect muscle cell metabolism? How do anabolic steroids affect muscle metabolism and consequently muscle size and appearance? What are the side effects of using anabolic steroids on other cells in the body?

What are the five most common types of cancer? Are any of them preventable? Choose one type of cancer and find out what scientists are currently doing to prevent and treat it.

The human body is about 50-65% water. Why do your cells need water? How does dehydration impair cell function? How much water can the body lose before it becomes dehydrated?

Project 2: Teacher Activity Notes - Cell Models

Summary

Students design and build three-dimensional (3-D) models of a particular kind of cell. They provide an explanation of all the structures and their functions in the cell. Studying cells is often easier when illustrations and models are employed to represent cell structures and functions. Students can create their 3-D model from materials of their choice or on the computer using design software.

Interdisciplinary Connection

Visual and Performing Arts

Duration

Two weeks to gather supplies or work on the computer

One week to build models in class or at home.

1-2 days to present models

Student Materials

Reference books, the Internet, medical and science illustrations, art supplies (such as clay, film, cardboard, markers, and/or paints)

Teacher Materials

None required

Advance Preparation

Give students time to bring supplies from home to build their model.

Products

Model of a particular kind of cell.

Written explanation of the structure and functions of cell organelles.

Presentation of model to class.

IMPLEMENT

1. As a class, brainstorm the possible cell types students could model. Discuss interesting materials from which they could build their models. Discuss how a 3-D model could be created and displayed on a computer. For example, a nerve cell, a muscle cell, a heart muscle cell, a red blood cell, a white blood cell.
2. Divide the class into groups of 3-4 students. Allow each group to choose a cell to model. Remind students that artistic talent is not of primary importance, rather they should concentrate on creating a clear and informative piece.
3. Provide students reference books with illustrations to research the specific structures that belong in their model. They also need to perform research on the functions of each structure and explain it in their own words.
4. Have students design a code key or legend for their model so that all parts are labeled and explained.
5. Have students present their models to the class.

ASSESS

Use the 3-D model of the cell and student presentation to assess if students can

- build an accurate model of a cell.
- describe the structure and function of each organelle and parts of a particular cell type.

7.3 Additional Resources

Textbooks

Biological Sciences, A Molecular Approach, BSCS 7th Blue Version. Evanston, Ill.: McDougal Littell.

Purves, Orians, and Heller, *Life*, 5th edition. Sunderland, Mass.: W. H. Freeman and Company.

Tortora and Anagnostakos, *Principles of Anatomy and Physiology*. New York: Harper and Row.

Books

Cells "R" Us

Internet Sites

American Cancer Society including the video-*The Intricate Cell* http://www.cancer.org

Human Genome Project Information http://www.ornl.goc/TechResources/Human_Genome/home.html

March of Dimes http://www.modimes.org/

The National Cystic Fibrosis Foundation

6931 Arlington Road

Bethesda, MD 20814

1-800-344-4823

http://www.df.org/

Video

The Cell Cycle: Mitosis and Cell Division-Biology Media

Cell Division: Mitosis and Cytokinesis-Carolina Biology Supply (also comes as a filmstrip version)

Cells, Tissues, and Organs-Coronet

Discovering the Cell- National Geographic

Molecular Biology-Coronet

Filmstrip

Understanding the Cell-United Learning (available as four filmstrips with cassettes)

Lazerdisc

BioSci II-Videodiscovery

CD Rom

Learning More About Cells-Science Kit and Boreal Laboratories (73923-00 Mac and 73923-01 Windows)

7.4 Live of Cells Glossary

active transport the use of energy to move materials from a region where they are in a lower concentration to a region where they are in a higher concentration.

adenosine triphosphate (ATP) a compound that stores energy.

amino acids molecules that are the building blocks of proteins.

cancer a change in the way cells are able to control their own reproduction.

cells the basic units (or building blocks) of life. They form the tissues, organs, and systems of the human body.

cell membrane (or plasma membrane) a membrane that surrounds the contents of the cell and separates it from other cells and the environment.

cell theory a theory that states that cells are the units of life and all cells come from preexisting cells.

cellular respiration a process in which glucose is broken down through a series of reactions to produce ATP, as well as carbon dioxide and water.

chromosomes large molecules in the nucleus made up of DNA and protein.

codon a triplet of mRNA nucleotides that directs the placement of an amino acid into a polypeptide chain.

connective tissue a group of cells that support and hold things together.

cystic fibrosis a genetic disease in which the affected person receives a mutated gene from both the mother and the father and has problems with recurring lung infections because certain cells in their lungs do not function properly.

cytoplasm fluid within the cell membrane of a cell that contains water and other chemicals.

diffusion the random movement of molecules from a region of higher concentration to a region of lower concentration.

diploid a cell that has two full sets of chromosomes. In humans, this is 46 chromosomes.

DNA polymerases special enzymes that carry out the neat and orderly replication process of DNA.

double helix two strands that twist around each other like coils. In biology, it refers to the double chain of nucleotides that form a molecule of DNA.

endoplasmic reticulum (ER) an elaborate membrane system throughout the cytoplasm.

enzymes proteins that help chemical reactions take place. Enzymes help cells build products like proteins, make copies of DNA molecules, and carry out all their functions.

epithelial tissue sheets of cells that form your skin, the lining of your breathing and digestive systems, and the covering of the organs of your body.

gamete cells sperm in males or eggs in females.

genes specific regions of the DNA that code for the production of specific proteins. Genes are responsible for specific products and functions characteristic of the particular cell type.

Golgi apparatus the flattened sacs that help sort the proteins synthesized by the rough ER and ribosomes.

haploid having one complete set of chromosomes. In humans a haploid gamete cell has one set of the 23 chromosomes.

helicase an enzyme that helps the DNA molecule start to unwind at one end.

meiosis a special kind of cell division that produces eggs and sperm. It involves two cell divisions, but only one duplication of the genetic materials, so that each daughter cell receives only one chromosome of each chromosome pair, or one complete set of the chromosomes for that organism.

messenger ribonucleic acid (mRNA) a type of nucleic acid that takes the code for a protein from DNA to the ribosome where the protein is produced.

mitochondria cell organelles that are the factory and storage center for ATP, which is used as energy by the cell in making cellular products and carrying out the functions of the cell.

mitosis cell division in which the parent cell reproduces into two identical daughter cells as a result of division of the duplicated chromosomes and division of the cytoplasm.

muscle tissue groups of cells that can contract.

mutation a permanent change in the DNA of a cell.

nervous tissue a group of cells that can process information and send messages or signals.

nucleotides repeating molecular units that make up DNA.

nucleus an important cell organelle that is the control center of the cell, containing the chromosomes with their genetic material, DNA.

organ a group of tissues that work together.

organelles the parts of the cell that are organized for specific functions, such as the nucleus.

osmosis the movement of water across a semipermeable membrane in response to a solute concentration difference.

passive transport the movement of a substance across a membrane due to a concentration difference and not requiring the expenditure of energy.

replication the process through which DNA is copied.

ribosomes the sites for protein synthesis.

RNA polymerase an enzyme that makes a complementary mRNA from the DNA template.

somatic cells almost all the cells in your body-the cells that make up the structure of your body and all your organs, such as the brain, heart, muscles, intestine, and liver. All cells except gamete cells.

stem cell a cell that divides to renew itself and, also, can give rise to many cell types.

stroke the blockage of, or break in, a blood vessel that serves a portion of the brain, causing the cells in that brain region to get sick and/or die.

system organs that work together.

tissue a group of similar cells working together to carry out a specific function.

transcription the process of making a messenger RNA molecule from a segment of DNA.

transfer RNA (tRNA) a type of RNA that brings the amino acids to the ribosomes to make proteins.

translation protein synthesis. The coded message in mRNA is translated to produce a protein.

tumors abnormal tissues produced when cancer cells continue to divide.