CAMBRIDGE CORE SCIENCE SERIES: BIOBASICS

CELLS: THE BUILDING BLOCKS OF LIFE

Teacher's Guide

INTRODUCTION

This Teacher's Guide provides information to help you get the most out of the *BioBasics: Cells: The Building Blocks of Life* video program. This program is the second of an eight-part *BioBasics* life sciences series. The information in this guide will allow you to prepare your students before using the program, and to present follow-up activities to reinforce the program's key learning points.

The *BioBasics* series is intended to excite young people about science and teach them concepts that meet national educational standards for science literacy. Science, in its multiple disciplines, is inherently fascinating and helps explain the world in and around us. In addition to fulfilling our natural curiosity, there is a practical benefit to studying science: it teaches critical thinking skills that help us make informed and reasoned decisions, solve problems, think creatively, and continue learning.

LEARNING OBJECTIVES

By viewing *Cells: The Building Blocks of Life*, students will be able to:

- Understand that every cell contains a "blueprint" coded in DNA molecules that specify how proteins are assembled to regulate cells.
- Determine that cells with similar functions have similar structures, and those with different structures have different functions.
- Discuss the fact that the structural basis of organisms is the cell, and that most organisms are single-celled.
- Recognize that cells function similarly in all living organisms.
- List the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.

EDUCATIONAL STANDARDS

The content of this program has been aligned with the following national and state educational standards and benchmarks.

NATIONAL STANDARDS

Science

The activities in this Teacher's Guide were created in compliance with the following *National Science Education Standards* from the Association for the Advancement of Science.

- As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry, and understandings about scientific inquiry.
- As a result of their activities in grades 9-12, all students should develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and behavior of organisms.

English Language Arts Standards

The activities in this Teacher's Guide were created in compliance with the following *National Standards for the English Language Arts* from the National Council of Teachers of English.

- Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts.
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.
- Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Technology Standards

The activities in this Teacher's Guide were created in compliance with the following *National Education Technology Standards* from the National Education Technology Standards Project.

- Students use technology tools to enhance learning, increase productivity, and promote creativity.
- Students use technology to locate, evaluate, and collect information from a variety of sources.
- Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

PROGRAM OVERVIEW

Bio Basics: Cells: The Building Blocks of Life provides viewers with a basic understanding of prokaryotic and eukaryotic cells, with an emphasis on the idea that the cell is the basis of life for all organisms. It also provides viewers with information on the common characteristics of and the differences between types of cells and their functions.

MAIN TOPICS

Topic 1: The Cell is the Basic Unit of Life

The cell is the simplest component of living matter that can carry out all the activities necessary for life. Cells can take energy such as light and sugar, and building materials (proteins, carbohydrates, and fats), and use them to repair themselves and reproduce. All organisms are made up of cells; the simplest life forms are made up of only one cell. The vast majority of organisms are single-celled, while more complex life forms are multicellular. The individual cell is actually a system unto itself. It is also a part of larger systems, such as complex organisms, and always part of an ecosystem.

Topic 2: Cell Theory

Modern cell theory states that:

- The cell is the basic structural and functional unit of life. All organisms are composed of cells.
- All cells are produced by the division of preexisting cells. Each cell contains genetic material that is passed down during this process.
- All basic chemical and physiological functions—repair, growth, movement, immunity, communication, and digestion—are carried out inside of cells.
- The activities of cells depends on the activities of sub-cellular structures within the cell (organelles, the plasma membrane, and the nucleus).

Topic 3: Cells are Microscopic

Most cells are microscopic. Only a few are visible to the human eye. Cells are so small because they need to maintain a membrane size large enough relative to their volume, so the membrane can work effectively to pass nutrients and information to and from the cell.

Topic 4: Cell Composition

Cells are composed of a small number of chemical elements (atoms and molecules) including carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur.

Topic 5: Cells Function Similarly in All Living Organisms

An organism is essentially a community of cells, each with common tasks and specialized functions. Cells transport materials and communicate information, transfer energy, build protein, dispose of waste products, and provide movement. Most of the cell's activities are carried out by the production of proteins. Proteins are large molecules which are made using the instructions contained within the cell's DNA (deoxyribonucleic acid), which is the cell's "blueprint." In complex organisms, cells perform a variety of functions. Function is determined by a cell's structure. Cells with similar structures perform similar functions.

Topic 6: Two Basic Cell Types

There are two basic types of cells: prokaryotic and eukaryotic. Bacteria and blue-green algae are the only organisms that are made up of prokaryotic cells, which are simpler and smaller than eukaryotic cells. All other organisms are composed of eukaryotic cells, which are more modern and complex. Typical plant and animal cells are eukaryotic.

Topic 7: Cells are Organized in Similar Ways

Every cell is covered by a plasma membrane, a complex structure made up of proteins and lipids (fats) that is in constant motion performing important functions for the cell. Cells also contain various internal, specialized structures, called organelles, in the cytoplasm that carry out the cell's work.

Topic 8: Plant Cells and Animal Cells Differ

Plant cells have certain characteristics which differentiate them from animal cells. Plant cells have cell walls, chloroplasts, and use the process of photosynthesis to convert energy from sunlight.

FAST FACTS

- Every cell is covered by a membrane that controls what can enter and leave the cell.
- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement.
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms.
- All life shares the same 20 amino acids.
- An adult human has over 50 trillion cells.
- Red blood cells are the only cells without a nucleus.
- Nerve cells are the longest cells in the body.
- Cell behavior can be affected by molecules from other parts of the organism or even other organisms.
- Gene mutation in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.
- Ten billion new white blood cells are made every day.
- Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact.
- No one is certain who invented the first microscope, but credit for the first compound microscope is usually given to Zacharias Jansen of Holland, who built it around the year 1595.
- In 1665, Robert Hooke discovered the cell when he examined a piece of cork under a microscope and saw that it was made up of small, empty compartments.
- A mouse and an elephant have cells of similar kinds and sizes. The only difference is how many cells are present.
- Most cells are totipotent, or have all of the information for making the complete organism.
- Groups of cells of the same type are called tissues.

VOCABULARY TERMS

active transport: Process in which a cell uses energy to transport a substance into or out of the cell.
amino acid: Building block of protein.
asexual reproduction: Reproduction requiring only one parent.
ATP: Substance in which cells store energy.
autotroph: Organism that can produce its own food, primarily through photosynthesis.
carbohydrate: Energy-rich substance found in foods such as vegetables, cereal grains, and breads; sugars and starches.
cell: Basic unit of structure and function in living things.
cell division: Process in which one cell divides into two cells, each of which is identical to the original cell.
cell membrane: Thin, flexible envelope that surrounds a cell and allows passage of materials into and out of the cell.
cell theory: Theory that all living things are made of cells, that all cells come from other cells, and that the cell is the basic unit of structure and function in living things.
cell wall: Outermost boundary of plant cells that is made of cellulose.
chloroplast: Cell organelle containing chlorophyll that is involved in the process of photosynthesis.
chromatin: Thread-like coils of chromosomes.

chromosome: Rod-shaped cell structure that directs the activities of a cell and passes on the traits of a cell to new cells.
compound: Two or more elements chemically combined.
cytoplasm: Region between the cell membrane and the nucleus.
diffusion: Process by which substances move from a higher concentration of that substance to a lower concentration of that substance; primary method by which substances enter and leave the cell through the cell membrane.
digestion: Process by which food is broken down into simpler substances.
division of labor: Division of work among the different parts of an organism's body that keeps an organism alive.
DNA: Nucleic acid that stores the information needed to build proteins and carries genetic information about an organism.
element: Pure substances that cannot be separated into simpler substances by ordinary chemical processes.
endoplasmic reticulum: Tubular passageways in the cell through which substances such as proteins are transported.
enzyme: Chemical substance that helps control chemical reactions.
excretion: Process of getting rid of waste materials.
fat: Substance that supplies the body with energy and also helps support and cushion the vital organs in the body.
fermentation: Energy-releasing process that does not require oxygen; less efficient than respiration.
heterotroph: Organism that cannot make its own food.
homeostasis: Ability of an organism to keep conditions inside its body the same, even though conditions in its external environment change.
ingestion: Taking in food; eating.
life span: Maximum length of time an organism can be expected to live.
lysosome: Small, round structure in a cell involved in the digestive activities of the cell.
metabolism: Sum total of all chemical activities in an organism.
mitochondria: Powerhouses of the cell in which cellular respiration occurs.
mitosis: Process in which the nucleus of a cell divides into two nuclei and the formation of two new daughter cells begins.
nucleic acid: Large, organic compound that stores information that helps the body make the proteins it needs; DNA or RNA.
nucleus: Cell structure that directs all the activities of the cell.
organ: Group of different tissues working together; the third level of organization in an organism.
organ system: Group of organs that work together to perform a specific function for the organism, the fourth level of organization in an organism.
organelle: "Tiny organs" that make up a cell.
organic compound: Compound found in living things that contains the element carbon.
osmosis: Term given for the diffusion of water through a membrane.
photosynthesis: Process by which organisms use energy from sunlight to make their own food.
protein: Substance used to build and repair cells, made up of amino acids.
respiration: Process in which simple food substances such as glucose are broken down and the energy they contain is released.
response: Some action or movement of an organism brought on by a stimulus.
ribosome: Protein-making site of the cell.
RNA: Nucleic acid that reads the genetic information carried by DNA and guides the protein-making process.
selectively permeable: Membrane that allows certain materials to pass through, but restricts other materials from passing through.
sexual reproduction: Reproduction usually involving two parents in which a sex cell from each parent unite to form offspring.

spontaneous generation: Hypothesis that states that life can spring from nonliving matter
stimulus: Signal to which an organism reacts; change in the environment.
stomata: Openings in the lower surface of the epidermis in a green plant that allows gases to enter and leave the plant's cells.
tissue: Group of similar cells that perform a special function in an organism, the second level of organization in an organism.
vacuole: Large, round sac in the cytoplasm of a cell that stores water, food, enzymes, and other materials.

PRE-PROGRAM DISCUSSION QUESTIONS

1. What questions do you think pre-cell theory scientists wanted answers to?
2. How do you think plant and animal cells differ? How do you think they might be similar?
3. How many cells do you think humans have? Plants? Fish? Why?
4. What schools of scientific thought (such as chemistry, botany, psychology, etc.) do you think benefit from advances in cell science?
5. In 1665, Robert Hooke discovered the cell when he examined a piece of cork under a microscope and saw that it was made up of small, empty compartments. What would you have thought if you had seen the same thing?

POST-PROGRAM DISCUSSION QUESTIONS

1. What is the importance in maintaining healthy DNA on the cellular level? What is the impact of a DNA "glitch"?
2. Which contribution to cell theory and cellular biology do you consider the most important? Why?
3. What does cell theory help us to understand?
4. How does your understanding of prokaryotic and eukaryotic cell development impact your understanding of evolution?
5. In complex organisms, cells perform a variety of functions. How is cellular cooperation and collaboration similar to interpersonal teamwork?

GROUP ACTIVITIES

Form Follows Function
Divide the class into four groups and have each group present an oral report on two of the organelles from the list below. For each organelle, have the groups discuss structure and function, and the relationship between the two.

- Cell membrane
- Nucleus
- Chloroplasts
- Golgi bodies
- Cell wall
- Mitochondria
- Endoplasmic reticulum
- Vacuoles

Flower Power
Divide students into groups, giving each group a different cut flower (a rose, daisy, carnation, iris, etc.), a bud vase or test tube, and liquid food coloring mixed with water. Have students put the flower (stem first) in the vase and pour in the food coloring solution, and ask them to track how long it takes for each flower's petals to turn colors. Students should report back in a week, and include the cellular explanation for the process.

Cell Crossword

Using cell vocabulary, have each student group develop a crossword puzzle or word-find, along with an answer key. Groups should exchange projects and solve the puzzles.

INDIVIDUAL STUDENT PROJECTS

History of Cells

Ask students to write an essay discussing the history of the discovery of cells. They should Include the cell theory and the scientists whose work contributed to it, as well as some historical background about the time period during which each scientist lived and worked.

The Conditions for Life

In this activity, students choose one animate (living) object and one inanimate (not living) object, and explain how each satisfies or does not satisfy the conditions for life. Students should provide concrete examples.

Conditions for Life

- Living things are organized.
- Living things reproduce.
- Living things grow.
- Living things respond to changes in their surroundings.
- Living things keep their internal environment unchanged.

Build a Cell

In this project, students may draw or build a model of both a prokaryotic cell and a eukaryotic cell. Ask them to label their parts, describe their functions, and highlight the differences between them.

INTERNET ACTIVITIES

Biology and Sociology in the News

In this activity, students use a major search engine, such as Google, to research current headlines in cellular biology, and their sociological (and political, if relevant) ramifications, such as stem cell research. Pick one story and present it to the class.

Cancer Research

Have students research the cellular nature of cancer in general, and then do further research on two or more particular types of cancer (such as breast, ovarian, prostate, melanoma, etc.). Have students contrast and compare the differences and similarities on the cellular level between the different cancer types.

Cells in Motion

In multicellular tissues, such as those found in animals and humans, individual cells employ a variety of locomotion mechanisms to maneuver through spaces. Have students use the Internet to view examples of these motions, such as the rapid movement of cells in developing embryos, organ-to-organ spreading of malignant cancer cells, and the migration of neural axons to synaptic targets. Students should describe their findings to the class.

ASSESSMENT QUESTIONS

Q: What is the name for the basic unit of life?

a) Atom
b) Molecule
c) Cell
d) Element

A: c) Cell
Feedback: The cell is the simplest component of living matter that can carry out all of the activities necessary for life. Cells can take energy such as light, sugar, and building materials (proteins, carbohydrates and fats), and use them to repair themselves and reproduce.

Q: Which of the following is not a subset of the cell?

a) Atom
b) Molecule or compound
c) Organelle
d) Organ

A: d) Organ
Feedback: An organ is a group of different tissues working together. It is the third level of organization in an organism.

Q: Who formalized cell theory?
A: Rudolf Virchow formalized cell theory.
Feedback: Cell theory was first proposed by the German botanist Matthias Jacob Schleiden and physiologist Theodore Schwann in 1838. It was then formalized by the German researcher Rudolf Virchow in 1858

Q: Which of the following functions are carried out inside of cells?

a) Movement
b) Repair
c) Growth
d) All of the above.

A: d) All of the above.
Feedback: All basic chemical and physiological functions—repair, growth, movement, immunity, communication, and digestion—are carried out inside of cells.

Q: All cells are microscopic. *(True or False)*
A: False
Feedback: While most cells are microscopic, a few are visible to the unaided eye. Eggs are an example of a cell visible to the naked eye.

Q: This character within quotation marks " - " is probably one nanometer long. *(True or False)*
A: False
Feedback: A micrometer is 1/1000th of a meter, or about the length of a "dash" in a word in a newspaper article. A *nanometer* is 1/100th of a micrometer.

Q: Name six chemical elements that comprise the atoms and molecules of cells.
A: Carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur
Feedback: These chemical elements are the molecular basis of life.

Q: The production of what carries out most of the cell's activities?
A: The production of proteins carries out most of the cell's activities.
Feedback: Proteins are large molecules which are made using the instructions contained within the cell's DNA (deoxyribonucleic acid). The DNA is the cell's "blueprint," which is made up of molecules that encode the genetic instructions that build various parts of the cell and tell it its function within an organism.

Q: What are the only organisms made up of prokaryotic cells?
A: Bacteria and blue-green algae are the only organisms that are made up of prokaryotic cells.
Feedback: Prokaryotic cells are simpler and smaller than eukaryotic cells, do not have a nucleus or other membrane-bounded internal structures that are typical of most cells, and have tough cell walls that make them resistant to environmental changes.

Q: What is every cell covered by?
A: Every cell is covered by a plasma membrane.
Feedback: The plasma membrane is a complex structure made up of proteins and lipids (fats), that is in constant motion and performs important functions for the cell, including: enclosing the cell and separating it from the other cells and environment around it; keeping the cell's shape; helping the cell regulate its internal environment; and transmitting signals and information to and from the cell.

ADDITIONAL RESOURCES

WEB SITES

Cells Alive!
www.cellsalive.com

The National Academy of Sciences
www4.nationalacademies.org

National Library of Medicine
www.nlm.nih.gov

BOOKS

Biology: Science for Life
By Colleen M. Belk and Virginia M. Borden
Prentice Hall, 1st edition; July 7, 2003; Paperback, 477 pages
ISBN: 0130892416

Biology: Concepts and Connections (4th Edition)
By Neil A. Campbell, Jane B. Reece, Lawrence G. Mitchell, and Martha R. Taylor
Benjamin Cummings; June 22, 2002; Hardcover, 781 pages
ISBN: 080536627X

Biology for Dummies
By Donna Rae Siegfried
For Dummies; September 15, 2001; Paperback, 384 pages
ISBN: 0764553267

OTHER PRODUCTS

The Nature of Biology, VHS/DVD, Cambridge Educational

Why study biology? What's it all about? Why does it matter? This is the video that helps answer these common questions about biology. Images from the natural world reinforce the sense of wonder and excitement involved in studying life science. Interviews with science professionals help viewers appreciate the impact and value of biology in society. The program is organized around the general themes of biology: Diversity of Life, Heredity, Cells, Interdependence of Life, Flow of Matter and Energy, and Evolution of Life. Through exploring these themes, students gain an understanding of the principles and values of life science. An upbeat introduction to the study of the living environment. A great way to begin a class in the life sciences! A Cambridge Educational Production. One 30-min video and guide.
Order #: 8181, www.cambridgeeducational.com, 1-800-468-4227

Themes of Biology, Posters, Cambridge Educational

This collection of seven posters combines striking photography, colorful illustrations, and succinct, informative text to represent these major themes of biology. Attractive resources for any science classroom, these educational posters help students make connections between key life science concepts and things they experience every day in the living environment. Posters include:

- Diversity of Life
- Classification
- Evolution
- Heredity
- Flow of Matter and Energy
- Interdependence of Life
- Cells

Order #: 27164, www.cambridgeeducational.com, 1-800-468-4227

Evolution Video Library, DVD, Films for the Humanities & Sciences

Part of the *Life Science* series, this program contains 17 video clips on evolution and natural selection, diversity of life, and genetics. Correlates to National Science Education Standards. A User's Guide is included, containing an overview; a numbered index of clips, with brief descriptions and lengths; suggested instructional strategies; and a list of additional resources. A Discovery Channel/FFH&S Production. Clips include:

- Introduction to Evolution
- Elephant Evolution
- Charles Darwin
- Adaptation
- Insect Evolution
- Survival
- Birds of Prey
- Reptile Characteristics
- Mammal Diversity and Survival
- Animals and Extremes
- Plant Diversity
- Introduction to Genetics
- Cloning
- Novelty Gene
- Crime Solvers
- Transgenics
- Biotechnology

Order #: 30954, www.films.com, 1-800-257-5126

For information on other programs

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