Elements of Biology
The Cell
Teacher's Guide

Grade Level: 9–12 | **Curriculum Focus:** Life Science | **Lesson Duration:** Two class periods

Program Description

Examine the structure of cells to see how they carry out everything from energy production to waste disposal to the storage of genetic material.

Lesson Summary

Students imagine that they are on the board of directors of a biotechnology company. They must assess the risks and benefits associated with tissue engineering and prepare a paper stating their position. Students research the topic and develop a position paper; throughout the process, they consult with their classmates, getting feedback to help them fine-tune their arguments.

Onscreen Questions

Part 1, "The Cell"

- What are the characteristics of prokaryotic cells?
- What are some differences between plant and animal cells?

Part 2, "The Power of Cells: Regenerating Life"

- Why might tissue regeneration be an improved method for healing injuries?
- What are some methods of creating living tissue?

Lesson Plan

Student Objectives

- Explain what is meant by the term "tissue engineering."
- Research tissue engineering, exploring its risks and benefits.
- Determine a viewpoint on this topic and support the position with research.

Materials

- *Elements of Biology: The Cell* program
- Computer with Internet access
- Paper and pencils

Procedures

1. Begin the lesson by asking students to write what they know about tissue engineering. If they are unfamiliar with the topic, tell them to indicate so on their papers and that it does not affect their grade. Then ask students to put their notes away until the end of the lesson.
2. Allow time for students to watch the segment "The Power of Life: Regenerating Cells." Then have them pair up and discuss the segment. Ask one or two pairs to report on their ideas.
3. Tell students to imagine that they are on the board of directors for a new biotechnology firm working in the field of tissue engineering. As a board member, each student must write a letter to the head of the company explaining his or her position about this research. In developing their positions, students should consider the following issues:
    - The practicality of executing this research
    - The long-term benefits of this research
    - The long-term risks
    - An assessment of the long-term prospects for this research
4. Give students time in class to work on their projects. The Web sites below have information on tissue engineering.

    - http://en.wikipedia.org/wiki/Tissue_engineering
    - http://www.whitaker.org/95_annual_report/tissue95.html
    - http://www.cs.cmu.edu/People/tissue/
    - http://pslgroup.com/dg/3170a.htm
    - http://tissue.medicalengineer.co.uk/Advantages+and+Disadvantages+of+Tissue+Engineering.php

5. For your information, below is some background material on this topic.
    - Tissue engineering is the building of new organs using cells from an individual that are then constructed on a human-made platform called a scaffold. Skin, cartilage, and kidneys have been successfully engineered.
    - Cells used in the construction of new tissues or organs can come from a matching donor or stem cells. Some controversy surrounds the use of stem cells for this purpose. Nonetheless,

tissue engineering shows promise as a way to provide tissue and organs for individuals in need, especially in light of the shortage of organs available for transplants.

- Rejection of the engineering tissue or organs remains a problem, just as it does with transplantation of donor organs. Shortage of cells needed for development of the artificial organs is another problem.
- Tissue engineering shows great promise. Blood and blood products, bone, and nerve cells have been engineered in the laboratory and are currently undergoing testing. Scientists hope to develop nerve cells and artificial thyroid cells that could produce T-cells, which are part of the body's natural defense against disease and infection.

6. During the next class period, give students time to finish their position papers. Then have students find a partner and exchange papers. Give students time to critique their classmates' work and discuss their ideas. Ask volunteers to share with the class.
7. Conclude the lesson by asking students to revisit their initial ideas about tissue engineering. What have students learned about this topic? What are their opinions about the future of tissue engineering?

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students thoroughly explained tissue engineering; demonstrated a clear understanding of the long-term risks and benefits of this research; developed a well-researched position paper that was supported by substantial evidence.
- 2 points: Students satisfactorily explained tissue engineering; demonstrated an adequate understanding of the long-term risks and benefits of this research; developed a satisfactorily researched position paper that was supported by some evidence.
- 1 point: Students could not or did not explain tissue engineering; demonstrated a weak understanding of the long-term risks and benefits of this research; developed a poorly researched position paper that was supported by little evidence.

Vocabulary

cell

Definition: The basic building block of life in an organism

Context: A cell's major parts—the nucleus, mitochondria, and other organelles—have a particular function that ensures that the cell gets the food and oxygen it needs to stay alive.

organ

Definition: A structure in the body composed of different tissues, each of which contributes to the overall functioning of that organ

Context: The heart has four kinds of tissue, all of which ensure that blood is pumped throughout the body.

organ rejection

Definition: The term used to describe the response of an individual's body to a new organ or tissue that it recognizes as foreign

Context: It has taken years of scientific research to find ways minimize the effects of organ rejection on the human body.

tissue

Definition: A group of similar cells that perform a particular function in the body

Context: Epithelial tissue makes up the skin, which protects the body's other organs.

tissue engineering

Definition: The construction of an organ in the laboratory by using cells from an individual's body grown on a human-made structure called a scaffold and then transplanted

Context: Scientists have successfully used techniques of tissue engineering to create skin and cartilage.

transplantation

Definition: The removal of a diseased organ and replacement with a healthy organ or tissues from another person

Context: The first successful kidney transplantation between identical twins took place in 1954 at Peter Bent Brigham Hospital in Boston, Massachusetts.

stem cells

Definition: A unique type of cell often harvested from embryonic cells that can differentiate into different kinds of cells in the body

Context: Although the use of stem cells is controversial, scientists may be able to increase the number of organs produced if a large enough supply is available.

Academic Standards

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site: http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

- Life Science: The cell

- Science and Technology: Abilities of technological design
- Science and Technology: Understanding about science and technology

---

DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. Introduction to Cells (2 min.)
At a microscopic level it's possible to see that all living organisms are made of cells. Get acquainted with the world of cells and their importance to life on Earth.

II. Simple and Complex (5 min.)
While they all share some common traits, cells are either prokaryotic or eukaryotic based on their structures and functions.

III. Animal or Vegetable (4 min.)
Explore the major differences between plants and animals and learn how both cell types create ATP, the primary source of chemical energy for all living things.

IV. Reproduction and Growth (4 min.)
Living things, including individual cells, expend time and energy to produce offspring and continue their species.

V. Regenerating Life (35 min.)
Explore the great accomplishments that medical researchers have made in the field of tissue regeneration, including the benefits to patients.

Curriculum Units

1. The Structures of Cells
Pre-viewing question
Q: What do you know about the structures of cells?
A: Answers will vary.

Post-viewing question
Q: What is the primary difference between prokaryotic and eukaryotic cells?
A: The location of the DNA differs in the two types of cells. In prokaryotes the DNA is bunched together in a nucleoid region, but it floats freely in the cytoplasm. In eukaryotes the DNA is separated from the cytoplasm by a membrane called a nucleus.

2. ATP in Organisms
Pre-viewing question
Q: What do cells need to function properly?
A: Answers will vary.

Post-viewing question
Q: Describe how heterotrophic and autotrophic cells create ATP.
A: All cells use adenosine triphosphate, or ATP, as the primary source of chemical energy. Most eukaryotic cells create ATP in cellular respiration, which takes place mainly in the mitochondria. In these organelles, glucose combines with oxygen to create carbon dioxide, water, and molecules of ATP.

Heterotrophic and autotrophic organisms differ in how they obtain glucose for this process. Heterotrophic cells must absorb glucose from an outside source. Plant cells are autotrophic, meaning that they make their own food by photosynthesis.

3. Structural Differences

Pre-viewing question
Q: What do you know about photosynthesis?
A: Answers will vary.

Post-viewing question
Q: What are the functions of the outer wall in plant cells?
A: Plant cells have a wall outside the cell membrane that provides support, keeping them upright and allowing them to grow without bending or breaking. It also helps orient plants toward the sun, which is necessary for photosynthesis.

4. Creating New Cells
Pre-viewing question
Q: What are some important functions of cells?
A: Answers will vary.

Post-viewing question
Q: Describe asexual reproduction in prokaryotic and eukaryotic cells.
A: Many cells reproduce asexually, meaning that they do not combine or trade DNA. The offspring of asexual reproduction are clones, or exact replicas of the parent cell. Most prokaryotic cells reproduce by a process called binary fission. During this process the cell replicates its DNA so that it has two copies and then splits in half.

Eukaryotic asexual reproduction is more complex. While a eukaryotic cell grows, it replicates its DNA so that it has two matching copies. During mitosis the parent cell arranges the two copies of DNA into matching pairs of chromosomes that are evenly split to form two matching nuclei. When mitosis ends, cytokinesis begins. In this process the eukaryotic cell's organelles and cytoplasm are split, and the parent cell physically separates into two daughter cells.

5. Regenerating Burned Tissue
Pre-viewing question
Q: Do you think it is possible for burned skin to completely regenerate?
A: Answers will vary.

Post-viewing question
Q: Why does a person's immune system automatically accept skin flaps grown in a laboratory?
A: Skin flaps grown in a laboratory are coated with a naturally secreted matrix of collagen and other proteins, which does not differ from one person to another. The immune system of a burn victim recognizes a flap as its own skin.

6. Growing New Cartilage
Pre-viewing question
Q: How might sports injuries cause permanent damage?

A: Answers will vary.

Post-viewing question
Q: What is a benefit of cartilage implant surgery over knee replacement?
A: Healthy cartilage cells from a person's good knee help grow replacement cartilage to be inserted into a damaged knee. The effect is long lasting, while knee-replacement surgery usually must be repeated.

7. Tissue Engineering
Pre-viewing question
Q: Do you think laboratory-generated body part might function as well as a natural one?
A: Answers will vary.

Post-viewing question
Q: Why is coral a good template for bone growth?
A: Coral is porous and its chemical content is very close to that of bone, minus the living cells. Over time a coral template breaks down naturally, which allows full regeneration of natural bone over the course of 16 weeks.

8. Making a Liver Healthy
Pre-viewing question
Q: What diseases and ailments affect the liver?
A: Answers will vary.

Post-viewing question
Q: How might tissue regeneration improve human health?
A: Answers will vary.