



## **BACKGROUND**

The cell is considered the basic unit of life. All living things on Earth are composed of cells. These living things can take the form of very simple unicellular organisms, such as bacteria, to large and complex multicellular organisms such as elephants or humans. Although we can generalize about animal cells, in a multicellular organism cells are specialized, they have specific jobs and these jobs are reflected in their shape. These specialized cells are organized into tissues, tissues organized into organs and specialized organs organized into complex organisms. Students will often be familiar with various different kinds of cells, discussing these will help to highlight the fact that cells are designed specifically for their jobs.

### ***Red Blood Cells***

There are about 25 trillion red blood cells in the human body. Red blood cells are unique in that they do not contain genetic material; they discard their nuclei soon after being made in the bone marrow. Red blood cells have a protein called hemoglobin that binds and carries oxygen to all of the other body cells. Red blood cells are made at the tremendous rate of 120 million every minute and live in the body for about 4 months. These small, round and flexible cells are well designed to travel through the narrow veins and capillaries of the circulatory system.

### ***White Blood Cells***

There are five major types of white blood cells in the human body. They each have specific functions but in general the job of the white blood cells is to protect the body from infection by viruses and bacteria. Two important types of white blood cells are the phagocytes and lymphocytes. Phagocytes eat bacteria that infect the body to protect it and also eat dead body cells. Lymphocytes make antibodies. Antibodies are proteins that specifically tag invaders for destruction. Like red blood cells, white blood cells are made in the bone marrow. There are 5,000 to 10,000 white blood cells in a drop human blood and this number increases when the body is infected with a virus or bacteria.

### ***Neurons***

Neurons, nerve cells or brain cells are the cells that make up the nervous system. These cells have long branches, called axons; the axons have smaller branches called dendrites. The long branches of the nerve cells make it possible to send messages long distances, and to receive messages from all areas of the body. Nerve cells carry messages around the body, from one nerve cell to another and from nerve cells to muscle cells. Until recently, scientists believed that nerve cells could not regenerate; that is, if a nerve cell was destroyed, a new cell would not be made to replace it. However, there is now evidence that some types of nerve cells are able create new cells.

### ***Muscles***

Muscle cells are responsible for movement. Muscle cells are long, thin and flexible. They are organized into bundles and a bundle of muscle cells make up a muscle. Muscle cells contain two important proteins, actin and myosin, which allow them to stretch. Unlike red blood cells, that do not have nuclei, muscle cells are multi-nucleated; they have more than one nucleus per cell.

## Form Fits Function

As mentioned previously, the shape of the cell is intrinsically connected to its job. This is a concept in biology referred to as “form fits function”. That is, the shape of a cell determines its job. The red blood cell provides an excellent example. The small, round, flexible shape of the cell makes it possible to fit through veins and capillaries; red blood cells often twist to fit through passages half the width of the cell itself. Sickle cell anemia is a disease where the red blood cells have an unusual shape; they are shaped like half moons or sickles. These cells tend to get stuck in narrow veins and block the flow of blood. When this happens, people with sickle cell anemia experience mild to extremely painful “crises”. These red blood cell aggregates can also lead to stroke, blindness, damage to lungs, kidneys or the heart. This disease provides an excellent example where a change in the shape of the cell interferes with the cell doing its job.

Although animal cells are specialized, when observed from the inside, they are very similar. In this way cells are similar to people. Humans beings look different from each other on the outside, but are all similar on the inside, everyone has a heart, lungs, muscles, skeleton, etc. All animal cells have similar parts that help them to do their specific, specialized jobs. The goal of this activity is to help students acquire an appreciation for the diversity of cell types and to learn the parts of a cell which helps it to do its job.

As will be further outlined, the cell can be compared to a factory. Like a factory, a cell consists of many individual parts that work together for a common purpose. These parts are described below.

### *The Cell Membrane*

The cell membrane provides the cell with its shape and structure. The cell membrane is made of lipids, or fats, which are stacked in two layers around the cell (lipid bi-layer). The cell membrane is a soft, flexible structure that protects the inside of the cell from the outside world. The cell membrane is semi-permeable. This means that the cell can allow substances it needs in through the membrane, such as oxygen and nutrients, and keeps substances that may harm the cell out.

### *Nucleus:*

The DNA is located inside the nucleus. The DNA does not leave the nucleus, instead it send messages out from the nucleus to rest of the cell.

### *DNA*

DNA is the hereditary material of the cell, arguably the most important molecule in the cell. DNA is arranged into a twisted ladder, or double helix, shape. The complete genetic instructions are present in each cell. In a human cell, if the DNA could be stretched out to its complete length, it would measure 6-8 ft or 2 m. To fit inside the nucleus, the DNA is packaged into 46 chromosomes. Chromosomes are passed from parents to children; each parent contributes 23 chromosomes to their offspring, resulting in a total of 46. DNA is an acronym for Deoxyribonucleic Acid, the full name of this molecule.

## **The Organelles**

The word organelle means “little organ”. The organelles are the microscopic organs of the cell, the individual workers that make it possible for the cell to conduct necessary life functions. Note that, like the cells discussed previously, each organelle has a distinct shape that qualifies it for its specific role.

### ***Mitochondria***

The mitochondria are responsible for converting glucose in the blood stream into a pure form of energy that cells can use. For this reason, the mitochondria can be considered the “power plants” of the cell.

### ***Endoplasmic Reticulum***

The endoplasmic reticulum, or the ER, acts as a hallway that molecules in the cell travel through. There are two types of ER: rough and smooth. The rough ER is covered with ribosomes and the smooth is not.

### ***Golgi Apparatus***

The role of the Golgi apparatus is to package molecules or proteins for secretion out of the cell. These secreted molecules act as messages sent from one cell to another.

### ***Lysosome***

The lysosome breaks down molecules in the cell. In human cells, lysosomes break down organic material to be re-used by the cell. For example, in a human liver cell, half of all the molecules in the cell are recycled every week.

## **Other structures**

### ***Ribosome***

Ribosomes make proteins. A messenger molecule, called RNA, carries instructions from the DNA for protein production to the ribosome. The ribosome “reads” the RNA and attaches amino acids together in a chain. This chain folds to make a protein. Proteins play very important roles in the human body, from the keratin that makes our hair, to the melanin that gives us our skin its color, and the enzymes of the digestive system.

### ***Microtubule***

Microtubules are rod-like structures that help the cell to maintain its shape. Microtubules can also act as a railway system that other molecules travel on to move through the cell.



## Description of Activity

This 1-hour lesson is an introduction to the basic structure and function of the animal cell for students in grades 5 through 8. Using a simple factory analogy, students learn how the major parts of a cell work together to make a product. Making a macroscopic cell model helps young people visualize the abstract world of the microscopic cell.

## Learning Outcomes

Students will:

- discuss the functional variation among animal cells.
- discover that in nature “form fits function”.
- identify organelles and other structures by their scientific names.
- learn how the organelles and other structures work together in a cell, much like in a factory.
- build a macroscopic model of an animal cell.

## Assumptions of Prior Knowledge

Students should know that microscopic cells are the building blocks of all living things. In animals, cells are arranged into tissues, tissues into organs and organs into organ systems.

## Misconceptions

Students may believe that all cells are exactly the same. Students might assume that because cells have different external appearances and functions, they will also vary greatly internally. Students may believe that the human body is one unit, and not a working system of many units.

## Lesson

### Materials and Equipment

- 250 ml beakers or 16 oz. plastic cups: 1 per student
- Empty soda bottle or jug for water
- Food storage bags, gallon size: 1 per student
- Paper plates: 1 per student
- Assorted beans: Navy, Pinto, Kidney, Lima, Split Pea: 1 package of each
- Spaghetti, broken into small pieces: 1 package
- 2 “ plastic eggs-1 per student
- Thread, 6-foot pieces: 1 per student
- Unflavored gelatin: 2 tbsp. per student

## Purchasing Information

- Plastic eggs- Oriental Trading Co.

## Before Class

- Prepare cell images to show students during lesson.
- Photocopy the corresponding student worksheets (Animal Cell diagram and Factory worksheet).
- Prepare a small “buffet” of beans and spaghetti. Each bean type should have it’s own plate.
- Prepare thread by cutting it into 6-foot lengths.
- Place a plastic baggie, plastic egg and 6” piece of thread into each beaker or cup.
- Fill empty soda bottle or jug with water.

## During Class

- Review how all living things are composed of cells and that they are considered “the building blocks of life.”
- Observe various cell types from photos or drawings (neurons, blood cells etc.). Remind students that cells are microscopic.
- Discuss that these cells have different external appearances because they have different jobs or functions. For example, the smooth round shape of a red blood cell helps it to travel through small blood vessels, while the long thin branchy shape of a nerve cell helps it to send signals to multiple cells of the body. Scientists call this “form fits function.”
- Discuss that although they may look different and have different functions, internally these cells are quite alike.
- Like factories, cells make products. These products are required for survival. Ask the students to list the various parts of a factory, such as the machines and workers, on the Factory worksheet.
- Pass out the Animal cell diagram and help students determine which cell structures look like they might have the same purpose/function as the items found in a factory. Record this on the Factory worksheet.
- Demonstrate that cells are factories that make proteins. For example, skin cells can produce the protein melanin, and hair and nails are made of the protein keratin.
- Help the students to determine which of the presented materials (beans, baggie, plastic egg, thread, gelatin, water) could represent each part of the cell in a model, and record on the Factory worksheet.
- Demonstrate how to assemble the cell model, and then ask each student to make a model as well.



### Analysis and Discussion

- Upon completion, instruct students to store their cell models in the refrigerator overnight. The gelatin should solidify.
- Discuss that in certain cells, because of their functions, one might find more of a certain type of organelle than in another cell. For example, muscle cells tend to have more mitochondria than other cells because of the energy demand.
- Discuss that almost every cell in the human body has the same DNA inside. Mature red blood cells and reproductive cells are exceptions. This means that potentially, almost every cell has all of the genetic information to create another person! Remind students that human babies are the result of a 9-month process of cell division that begins with a single fertilized egg.
- A fun review activity might be to dissect the cells and re-visit the various internal structures.

### Further Explorations

Make plants cell models and discuss the differences between plant and animal cells. Split peas can be used to represent the chloroplasts.

Make an “edible cell” with gelatin and fruit, or cake and candy.

Assign students individual organelles or cell types to report on. Students can give presentations to the rest of the class.

Students can discuss the transport of water into and out of the cell (osmosis) through the cell membrane. If no microscopes are available, place a slice of potato in distilled water and another slice in a salt solution. One will become soft and mushy while the other becomes firm. Discuss how the cells have lost water from the cytoplasm in salty water, but took in water to become firmer in distilled water.

### Resources

#### Websites

[www.cellsalive.com](http://www.cellsalive.com)

Quill Graphics. This Internet site has fantastic electron micrographs of real cells.

<http://www.dnafb.org>

A Dolan DNA Learning Center Internet site.

Use this site to explore various genetics concepts from inheritance to genetic engineering.

<http://www.dnai.org>

A Dolan DNA Learning Center Internet site.

Use this site to learn about the past, present and future of DNA science.

#### Films

“The Secret of the Code”

3-2-1 Contact, Children’s Television Workshop, 1991.

“The Intricate Cell”

American Cancer Society

ACS Code: 2366.05

#### Books

[Enjoy Your Cells](#)

Fran Balkwill and Mic Rolph, CSHL Press, 2002.

[Have a Nice DNA](#)

Fran Balkwill and Mic Rolph, CSHL Press, 2002.



## Correlations

### New York State

NYS Standard 4: Science

The Living Environment

- Living things are both similar to and different from each other and nonliving things.
- Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.
- The continuity of life is sustained through reproduction and development.

### National

Content Standard C: Life Sciences

Structure and functions in living systems

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and functions include cells, organs, tissues, organ systems, whole organisms and ecosystems.
- All organisms are composed of cells—the fundamental unity of life. Most organisms are single cells; other organisms, including humans, are multi-cellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for work that cells do and to make the materials that a cell or an organism needs.
- Specialized cells perform specialized functions in a multicellular organism. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as whole.

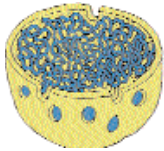
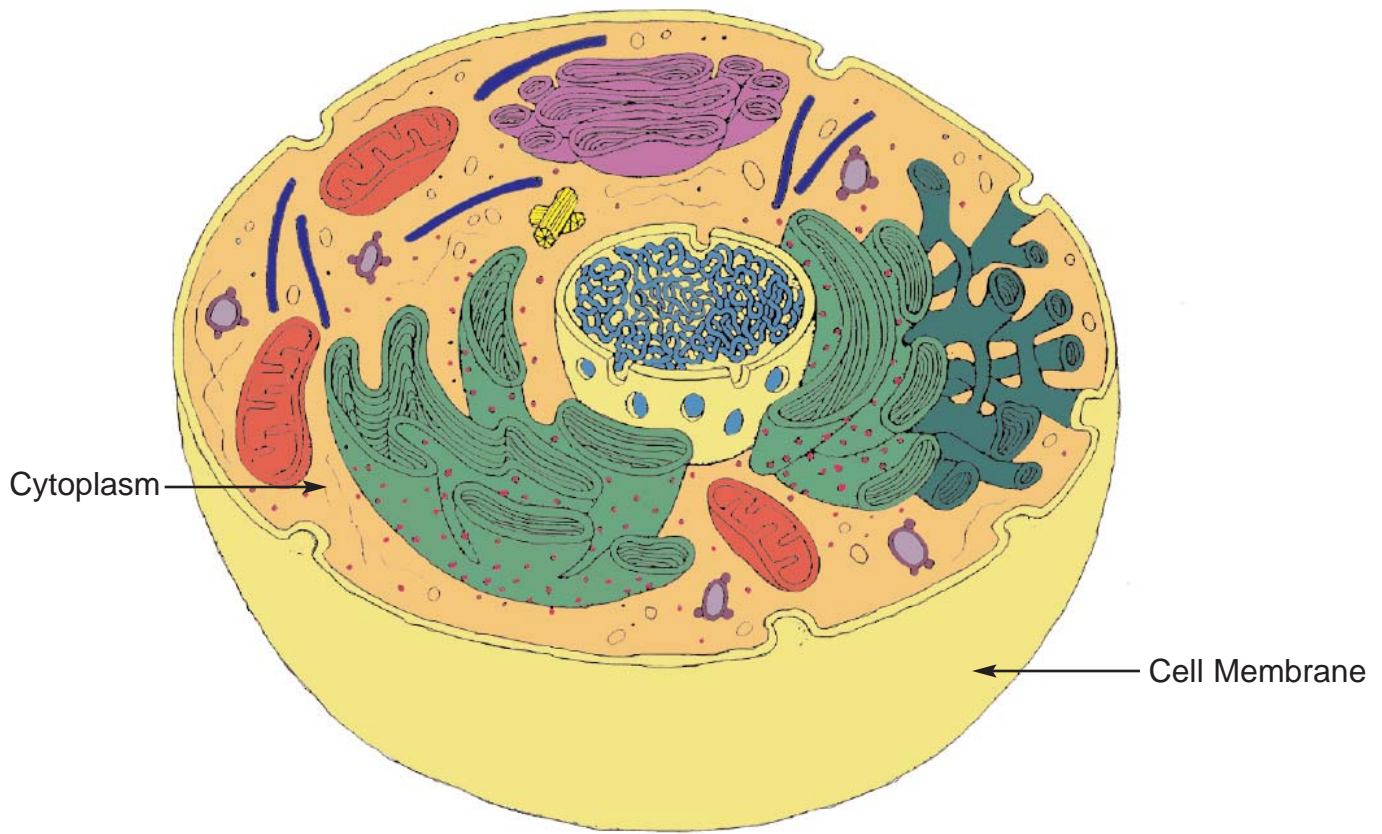
## AAAS Benchmarks

Standard C: Cells

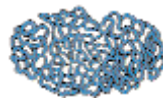
- Some living things consist of a single cell. Like familiar organisms, they need food, water and air; a way to dispose of waste; and an environment they can live in.
- Microscopes make it possible to see that living things are made mostly of cells.
- Some organisms are made of a collection of similar cells that benefit from cooperating. Some organisms' cells vary greatly in appearance and perform very different roles in the organism.



# The Animal Cell

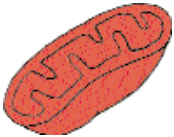


**Nucleus**

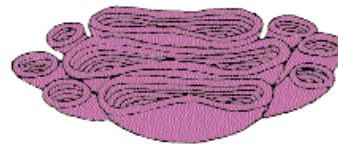


**Deoxyribonucleic Acid (DNA)**

## The organelles and other structures:



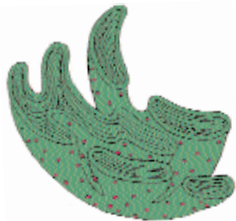
**Mitochondria**



**Golgi Bodies**



**Ribosomes**



**Rough Endoplasmic Reticulum (ER)**



**Smooth Endoplasmic Reticulum (ER)**



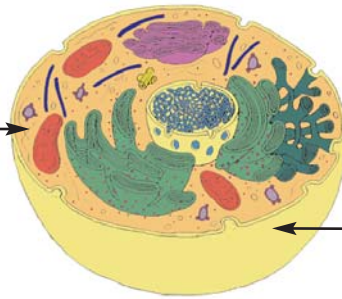
**Lysosome**



**Microtubule**

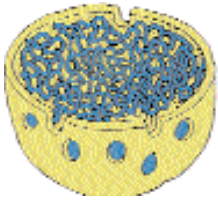


The **cytoplasm** is the liquid environment of the cell. It is made mostly of water.

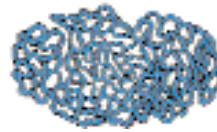


The **cell membrane** covers the surface of the cell and helps to give the cell its shape. It also controls what enters and exits the cell.

## The genetic material:

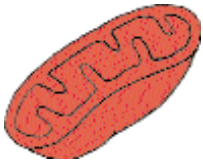


The **nucleus** is the storage center of the DNA. The nucleus is separated from the rest of the cell by a nuclear membrane.

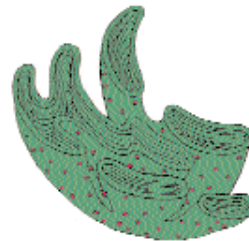


**Deoxyribonucleic acid (DNA)** contains the instructions cells follow to carry out life functions.

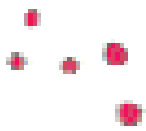
## What do the organelles and other structures do?



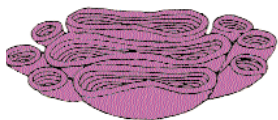
The mighty **mitochondria** produce energy for the cell.



**Rough endoplasmic reticulum (ER)** is a pathway for molecules that travel through the cell. It is called rough because there are many ribosomes on its surface.



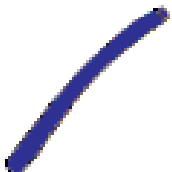
**Ribosomes** make proteins. There are millions of ribosomes in an average human cell.



**Golgi bodies** package proteins that are sent out of the cell.



**Smooth endoplasmic reticulum (ER)** is also a pathway in the cell. It is called smooth because there are no ribosomes on its surface.



**Microtubules** help to support the cell's structure.



**Lysosomes** are trash compactors of the cell. They store and break down materials from the cell.

# How is a cell like a factory?

Factory	Cell	Model